

● ONLY ● COUNTRY  
LASTS FOREVER

# **Prosperous future, new industries and the energy transition**

## ***– Can Australia really do it?***

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Dr Cathy Foley

Australia's Former Chief Scientist

2025 FEnEx CRC Annual Conference

1 May 2025



**LUCKY?**

# 61 years ago

Australia is a lucky country run mainly by second rate people who share its luck. It lives on other people's ideas, and, although its ordinary people are adaptable, most of its leaders (in all fields) so lack curiosity about the events that surround them that they are often taken by surprise.

Opening words to last chapter of the book *The Lucky Country* by Donald Horne

— Analysis

# Australia is rich, dumb and getting dumber



**Aaron Patrick**

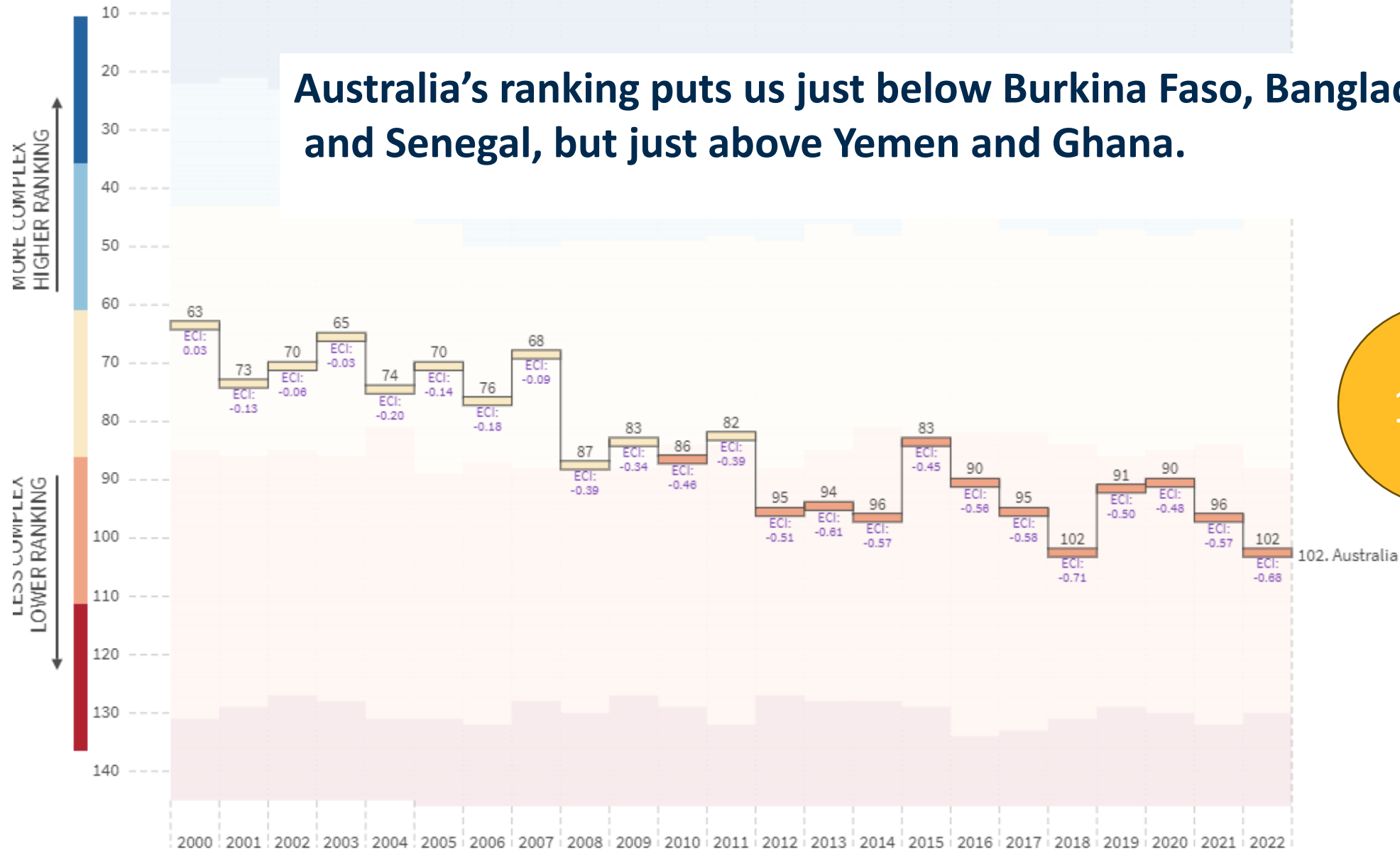
*Senior correspondent*

Oct 8, 2019 - 12.00am

Bangladesh, Cuba, Iran, Mali and Turkmenistan share an unexpected connection to Australia, and it isn't membership of a tourist destination hot list.

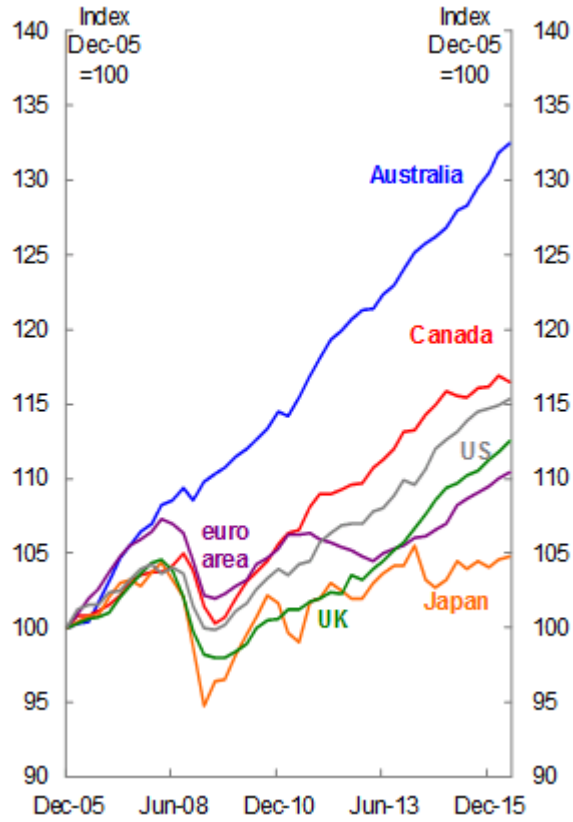
All are among the economies that are so lacking in complexity, and have such limited natural opportunities to develop new products, that Harvard University recommends they adopt industrial policy straight out of the post-colonial developing world: the "strategic bets" approach.

Australia's ranking puts us just below Burkina Faso, Bangladesh, and Senegal, but just above Yemen and Ghana.



102<sup>nd</sup>

102. Australia

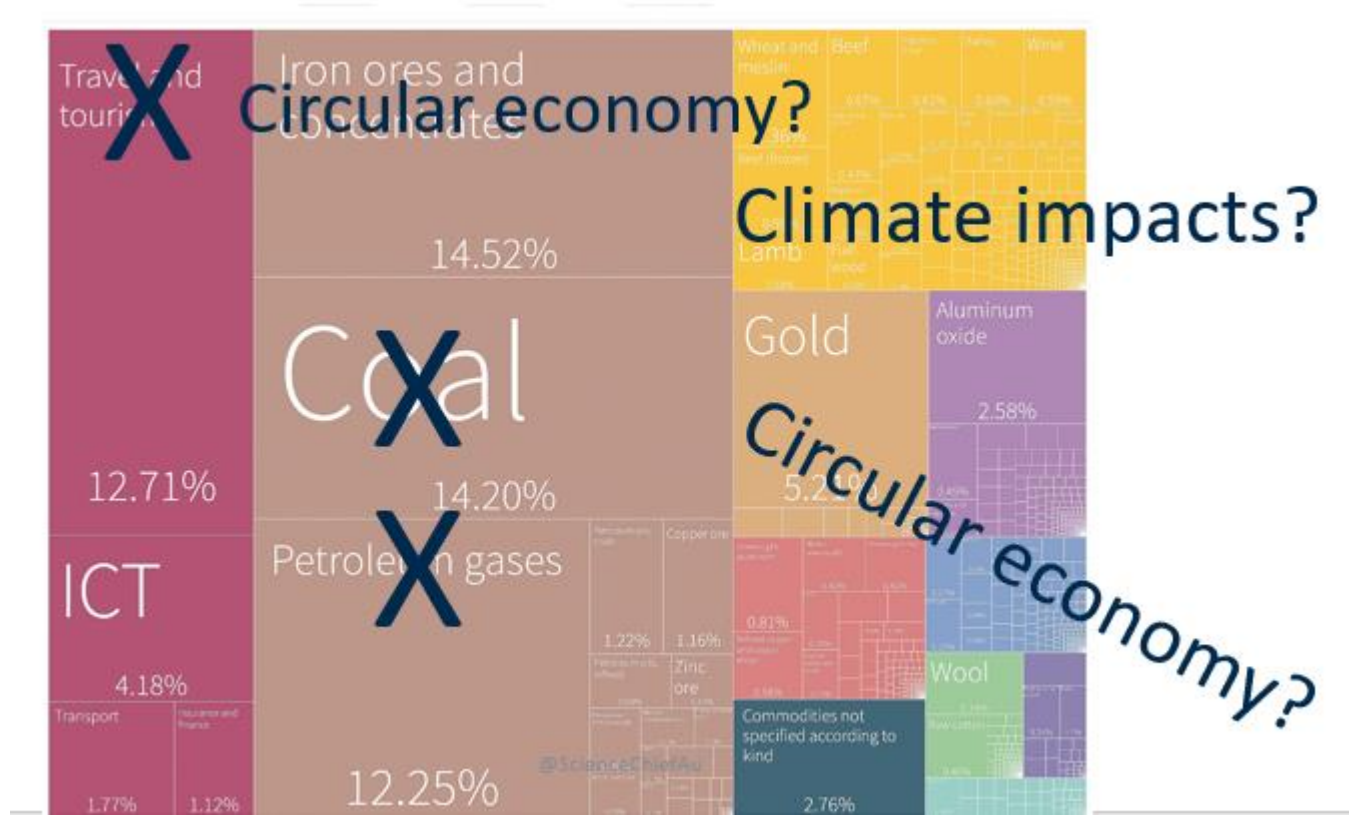


COVID

Energy transition

Circular economy

Geopolitics



## Trade



## Technology



## Research



0.3%



# Comparative advantages

- **Oldest continuous culture on Earth**
- **Multicultural society with cohesion and inclusivity**
- **Natural endowments**
  - Sunlight and wind
  - Lots of land
  - Unique biodiversity
  - Shoreline from tropics to artic
- **Liberal democracy with quality government leadership and public service**
  - Values evidence based decision making
  - Follow the rule of law with strong federal structure and institutions
  - Education system that enables a skilled work force
  - Strong and respected research sector
  - Universal health system
  - Superannuation
  - Social safety net
- **Liveable cities**
  - Excellent clear water and sanitation
  - Safe food
  - Quality infrastructure
- **Continuous (mostly) economic growth for more than 3 decades**
  - Close to high economic growth area (S.E. Asia)
  - Start-up culture explosion



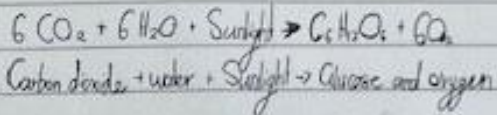
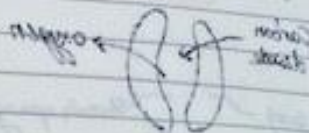
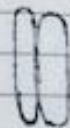
**AUSTRALIA... A BIG COUNTRY!**



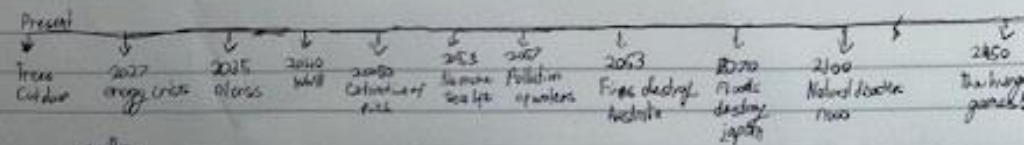
# Plant Energy/Nutrients

Where do we get our energy from?

- Food/Nutrients
- Sleep
- Water
- Mindset
- Exercise



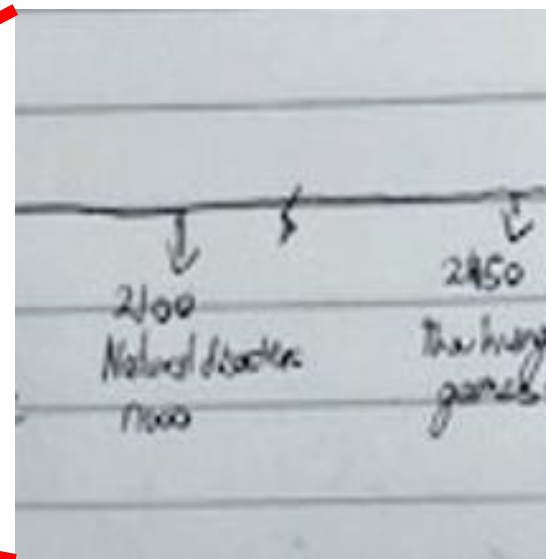
- 1- Carbon dioxide ( $\text{CO}_2$ ), water ( $\text{H}_2\text{O}$ ) and sunlight are taken in by a plant
- 2- A plant produces glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) and oxygen ( $\text{O}_2$ )
- 3- Sunlight is the energy source used to power photosynthesis, and chlorophyll is green.
- 4-  $\text{CO}_2$  is carbon dioxide,  $\text{H}_2\text{O}$  is water, and  $\text{C}_6\text{H}_{12}\text{O}_6$  is glucose.
- 5- Cutting down trees is a way of creating space, however, it is, so to speak, destroying our earth and its environment. As well as reducing animal habitats, leading to the potential extinction of important species and so.



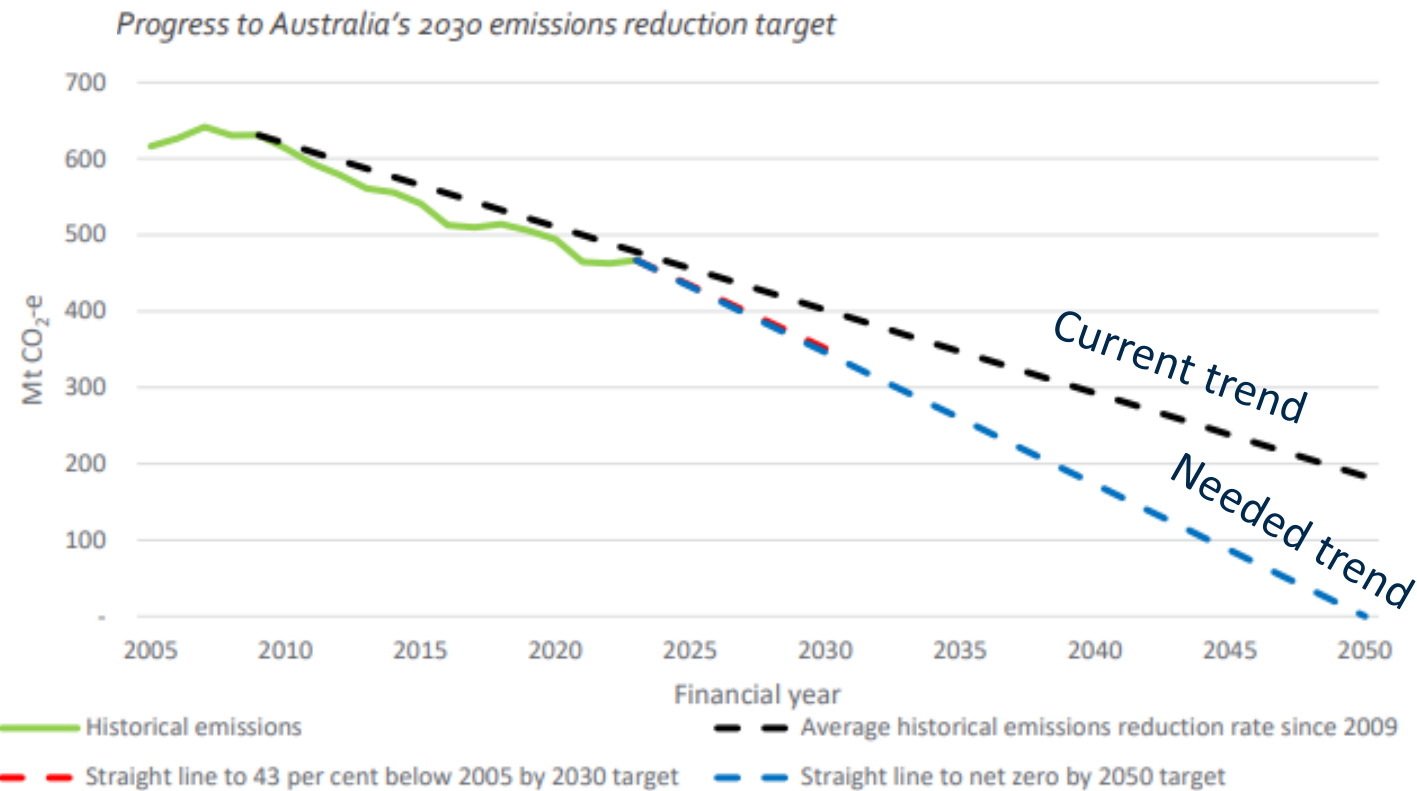
million  
10 billion years later.

The solar system explodes:  
And everyone dies except for the few who established a civilization in the neighboring dimensions. Then 100 SD (Safety Dimension) years later a girl named Laurel Thomson goes back to see what happened to it but she ends up in medieval times... what follows is the plot of "Laurel Thomson Made the Earth", a book I hope to release as an adult.

Hannah from year 9 now year 11  
at Burwood Girls High  
April 2023



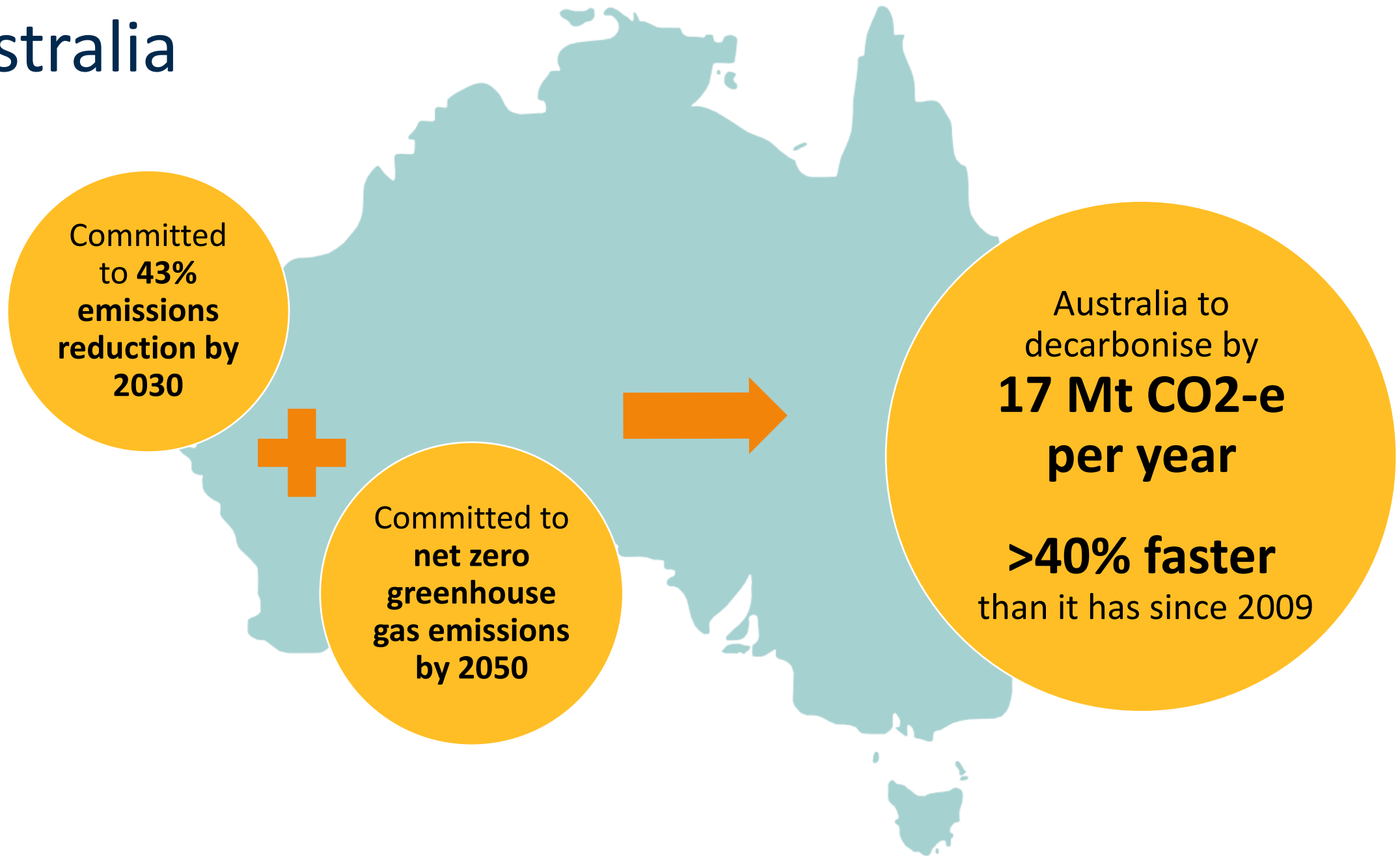
# Need to address climate change quickly so what does this mean for energy?



Notes: Includes preliminary estimates of emissions from April to June 2023.

Source: (DCCEEW, 2023m; DCCEEW, 2023cc)

# Australia



# How much is 17 Mt CO<sub>2</sub>-e per year?

That is equivalent to electrifying Australia's whole fleet of 3.5 million light commercial vehicles in one year



**180,000  
electric  
vehicles  
now**

**1% are  
light  
commercial**

# Early downscaling

E+ in 2050, solar and wind with transmission

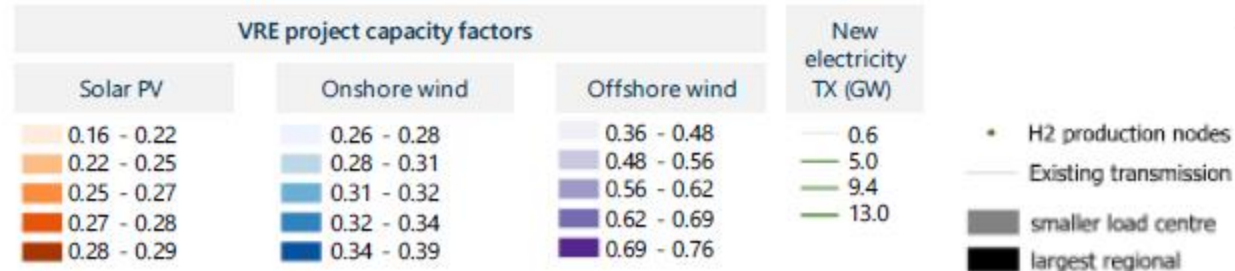
## Net Zero Australia projects

- 1.9 TW solar PV (2,242 projects)
- 132 GW onshore wind (194 projects)
- 42 GW offshore wind (36 projects)

Electricity generation is about **40x the capacity of the National Electricity Market** (in 2022).

## NATIONAL MAP - 2050

**INDICATIVE ONLY**  
Purpose of downscaling is to show scale and pace of change, not to identify specific projects



# Technology change and adoption

2005



Luca Bruno / AP

2013

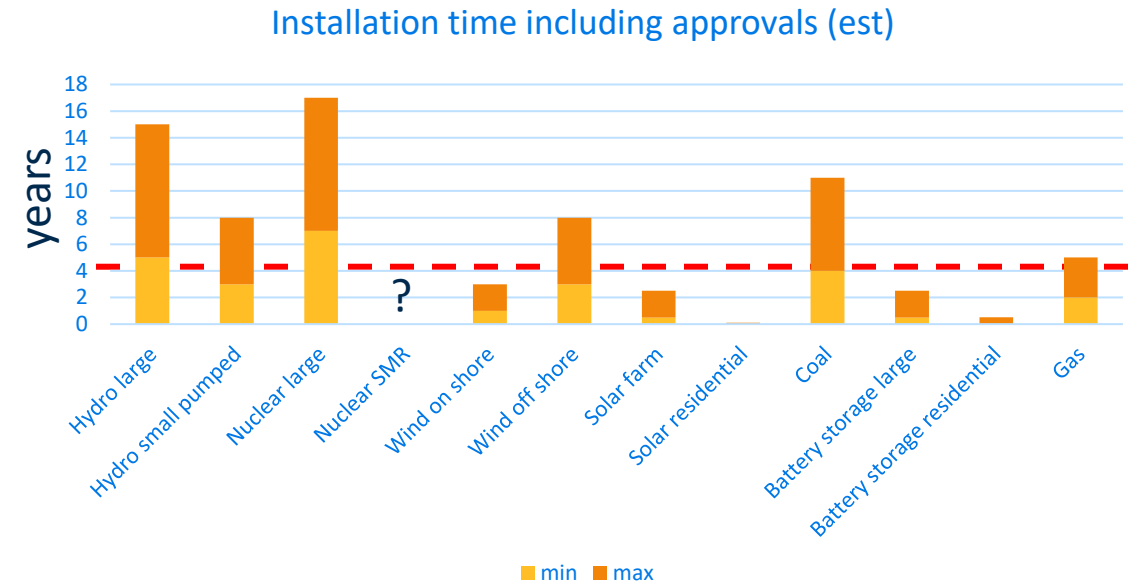
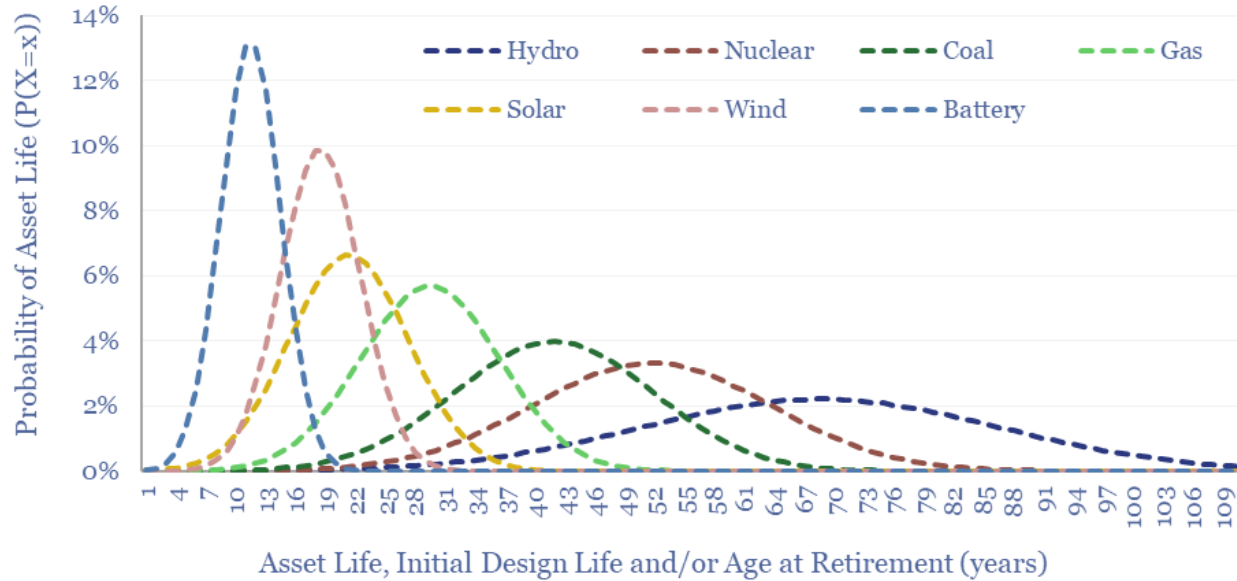


NBC NEWS

Michael Sohn / AP



# Energy tech asset lifetimes and installation times



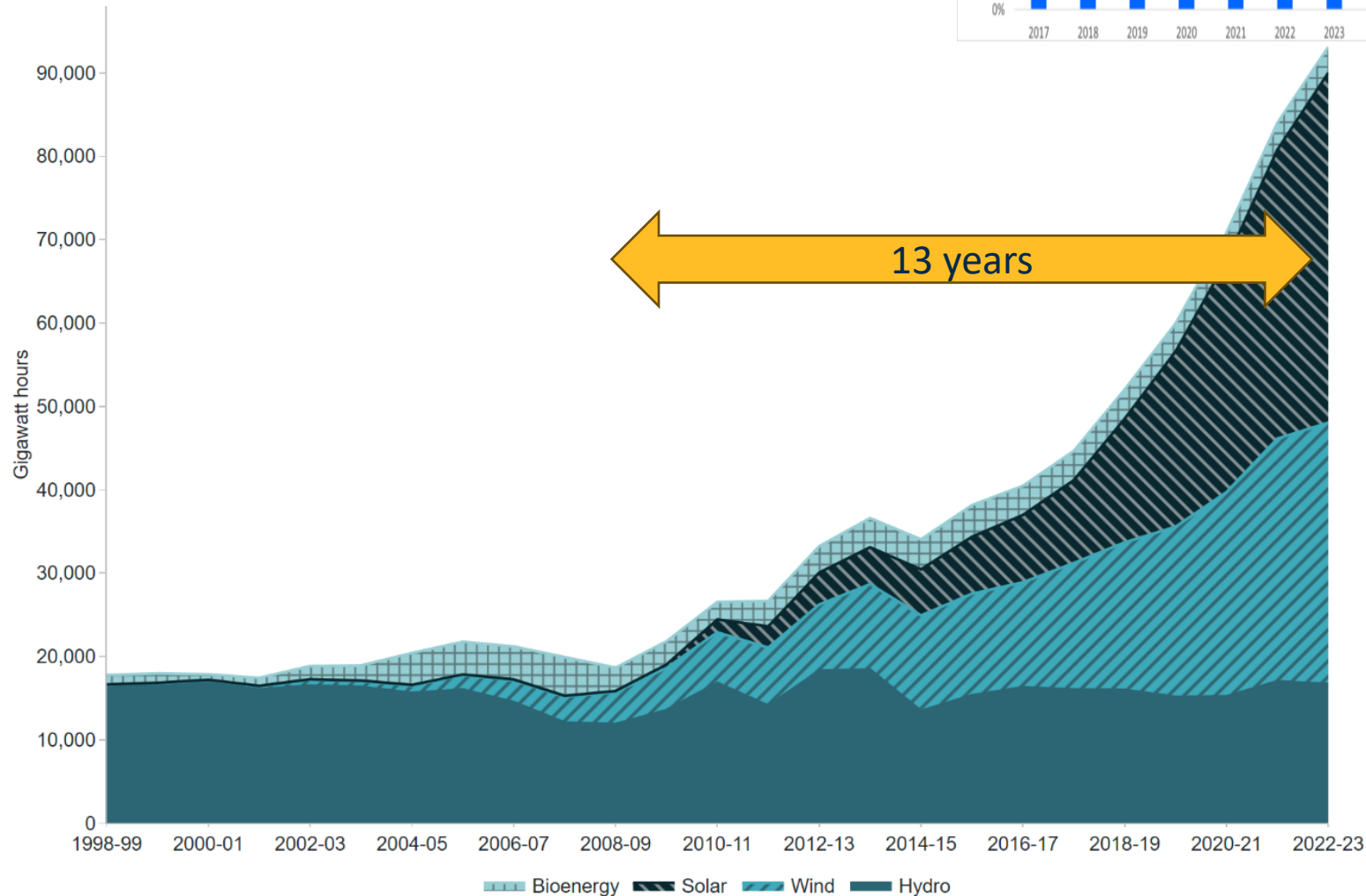
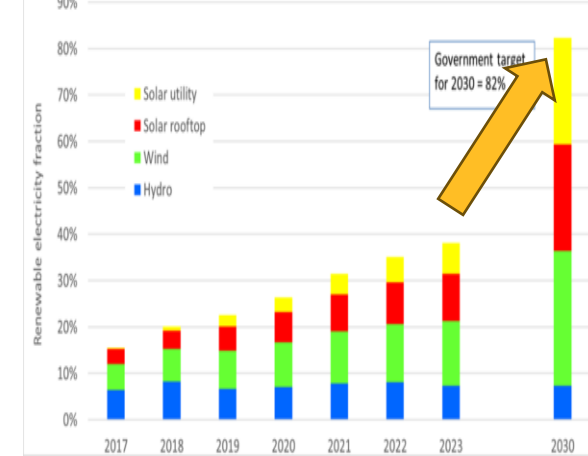
1900



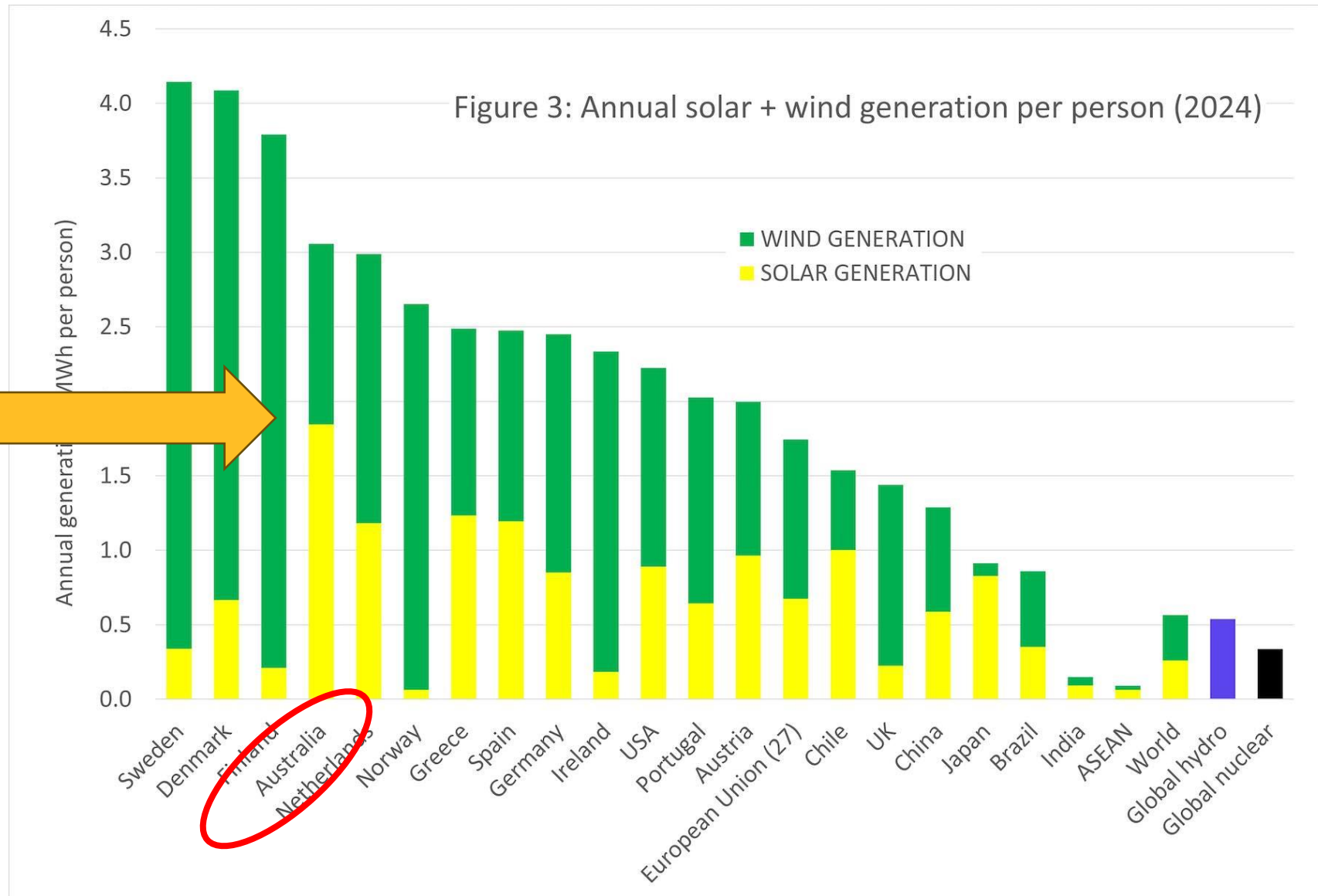
1913



# Rapid growth last 13 years

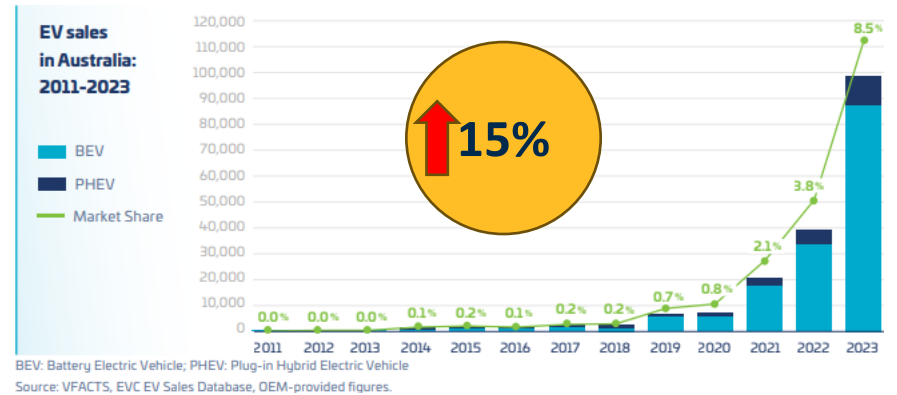


# So far – PV and wind adoption and rate of change



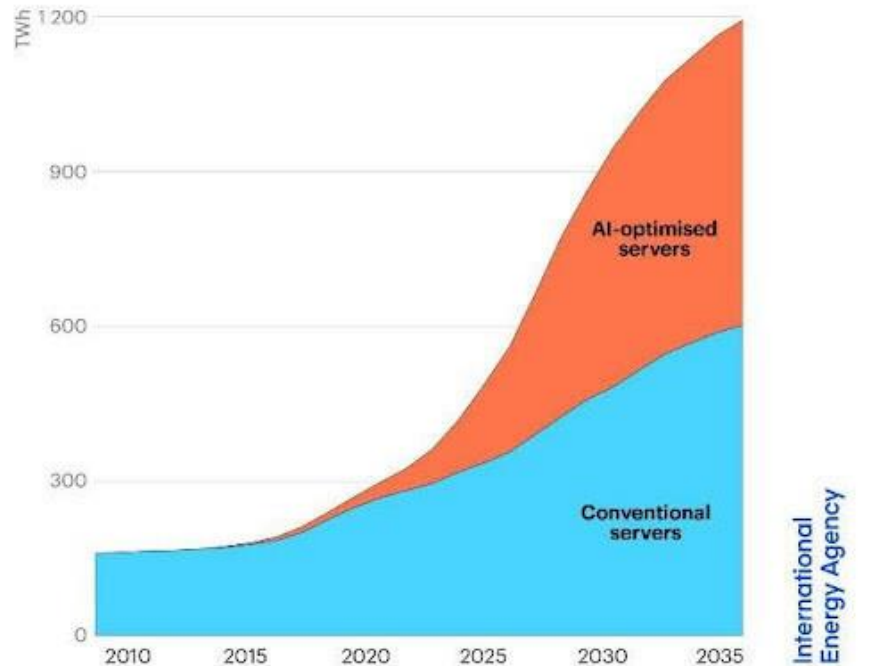
# Energy use will grow

- EV use
- AI
- Population growth – noting we are heading to a plateau
- Low GDP countries increase in standard of living
- Climate adaption

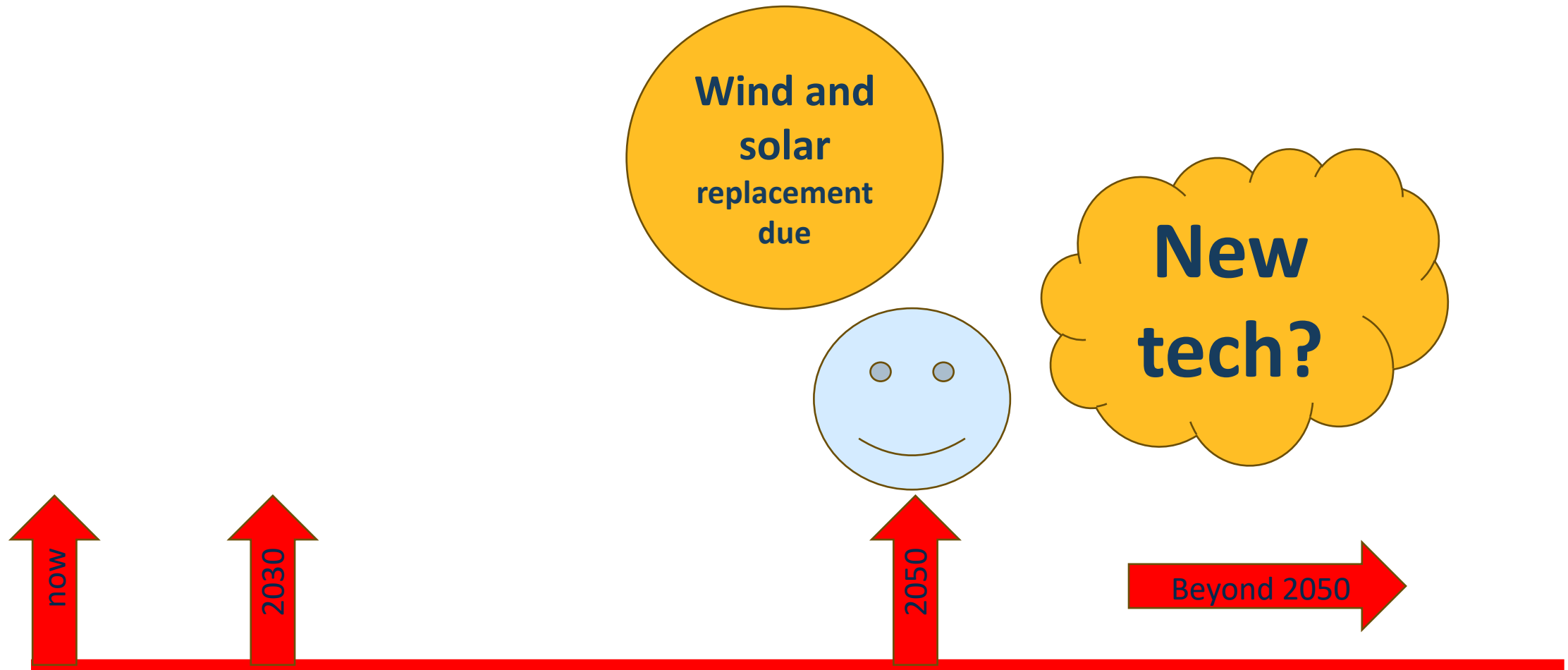


## Data centre electricity demand is set to surge in the next decade, driven by AI

Data centre electricity demand, historical & projected through 2035



# Next gen energy?



# Questions for the future

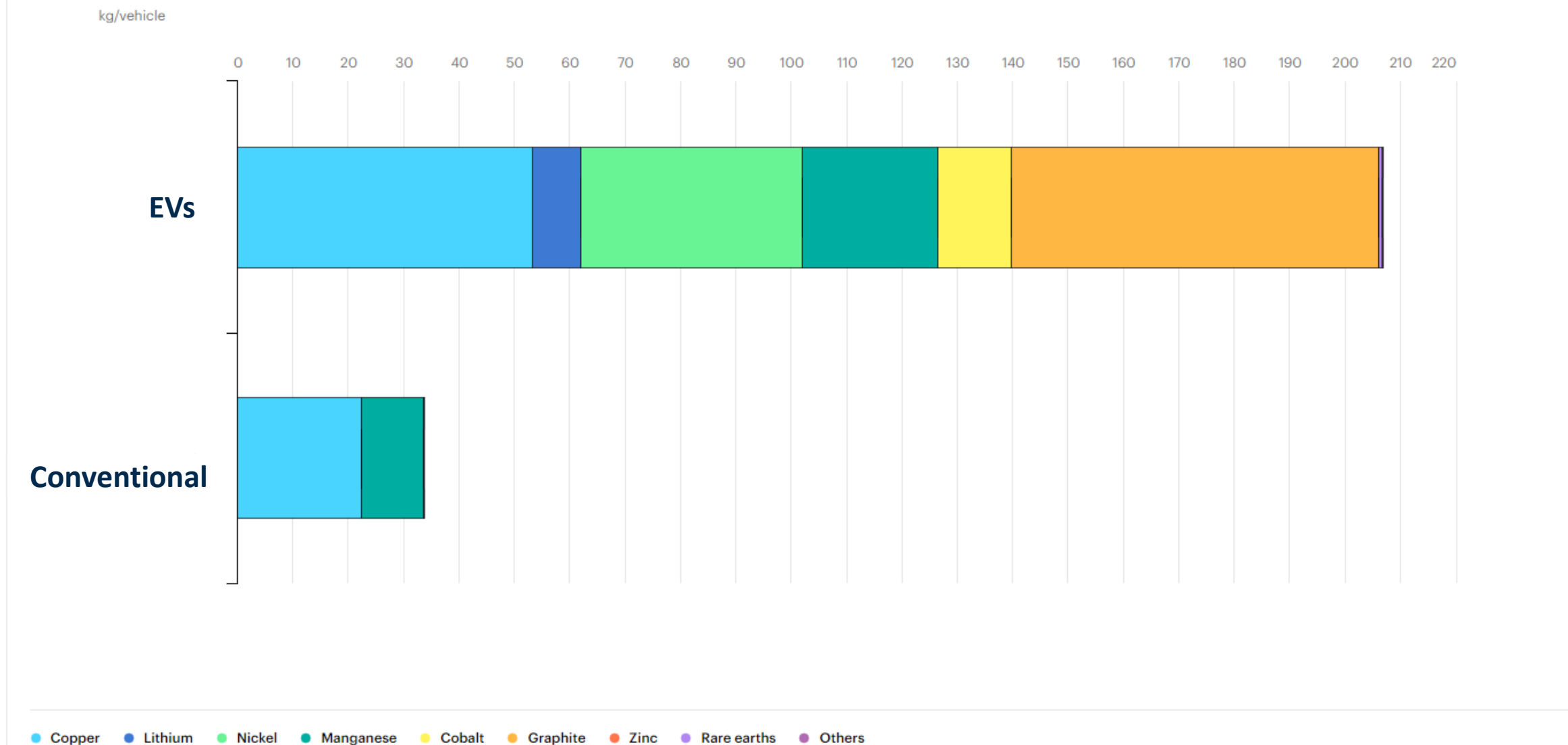
- How much energy is needed?
- What is the future market scale?
- What will happen when current PV and wind get to end of life?
- What new tech is on the horizon?
- What tech can we use now that is not yet adopted?
- What “old” tech could be upgraded?

# How do to transition our economy and use the opportunity when there are other pressures

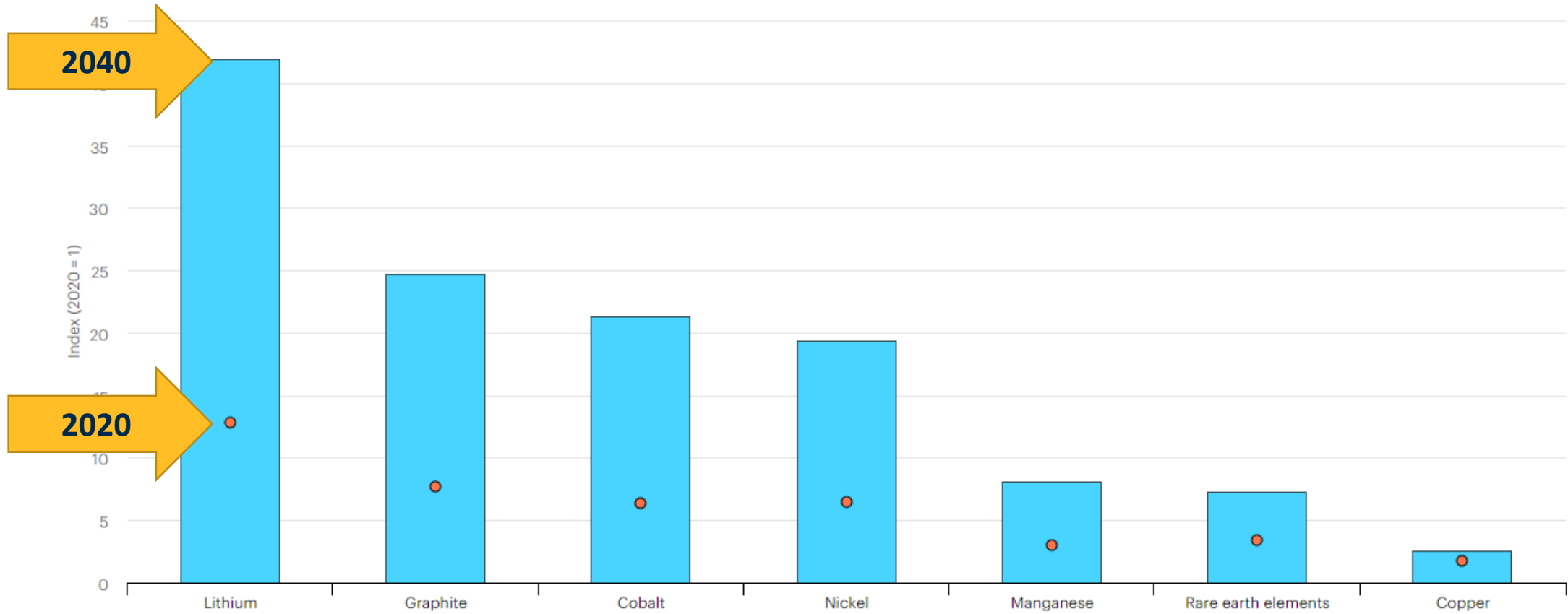
- Materials
- Supply chain
- New tech takes over
- Circular economy
- ESG
- Geopolitics changing rapidly



# Minerals used in electric cars compared to conventional cars



# Growth in demand from 2020 to 2040



IEA. Licence: CC BY

# What is currently on the cards?

- By 2030, to meet demand for electricity storage alone, the world will require:
  - **50** new lithium mines,
  - **60** new nickel mines and
  - **17** cobalt mines.
- Global mining investment
  - increase by US\$100 billion annually required for the world to achieve net-zero emissions by 2050.
- The economic opportunities this presents for Australia are significant
  - but not guaranteed.
- Needs:
  - favourable investment conditions - the opportunity will be missed
  - long lead time that exists from discovery to production for new mines – up to 18 years for a nickel mine
  - Australia has over 100 prospective mining and processing projects totalling about \$50 billion of investment a
  - potentially providing around 30,000 construction jobs and 20,000 operating jobs

***What happens if battery technology changes?***

# *What will the next generation of solar cells be made of?*

## Be adaptable

Some of the first solar cells were made out of Germanium in the early 1950s....

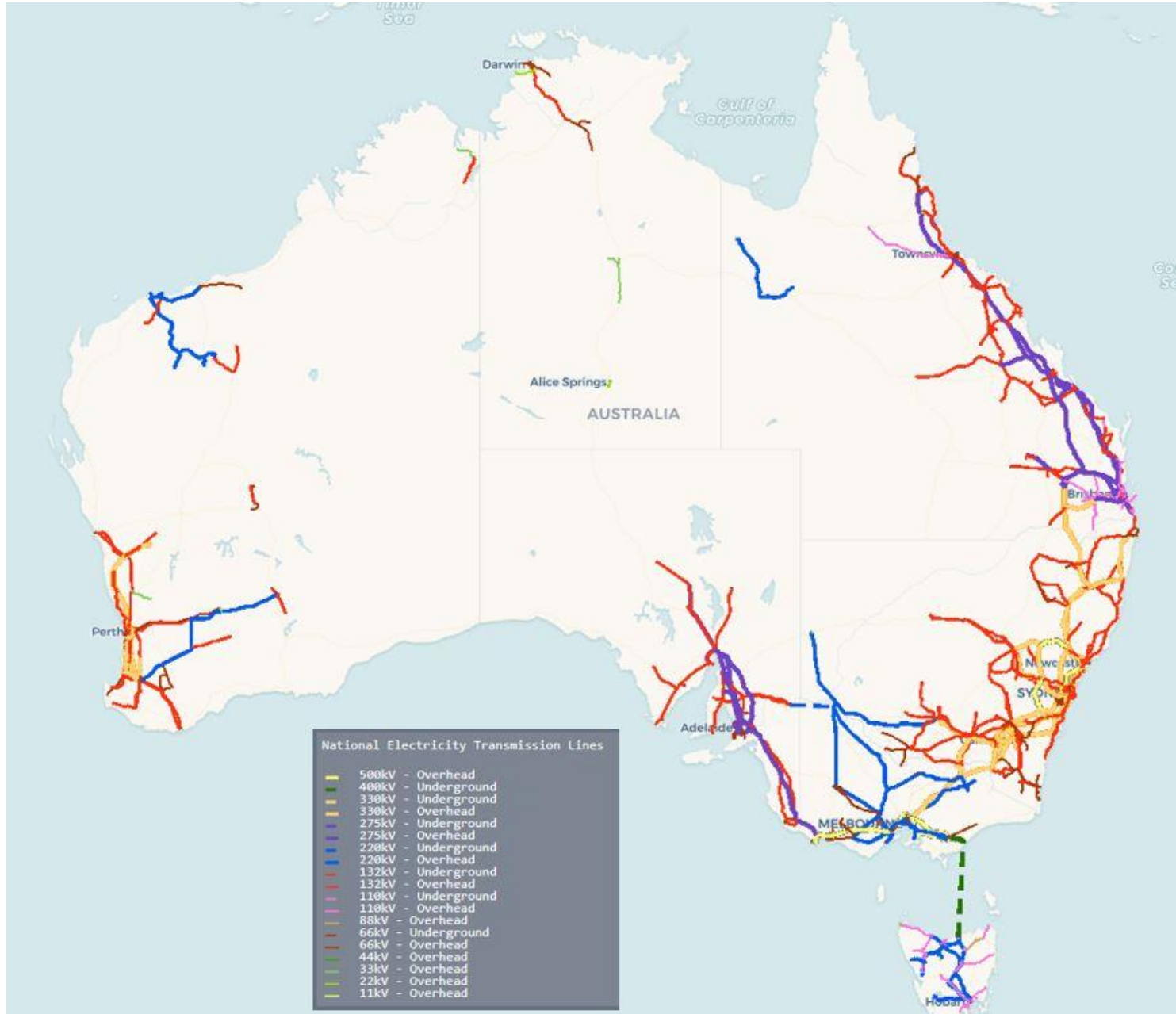


And this looked like the most promising technology until the first usable silicon solar cell was made in 1963...



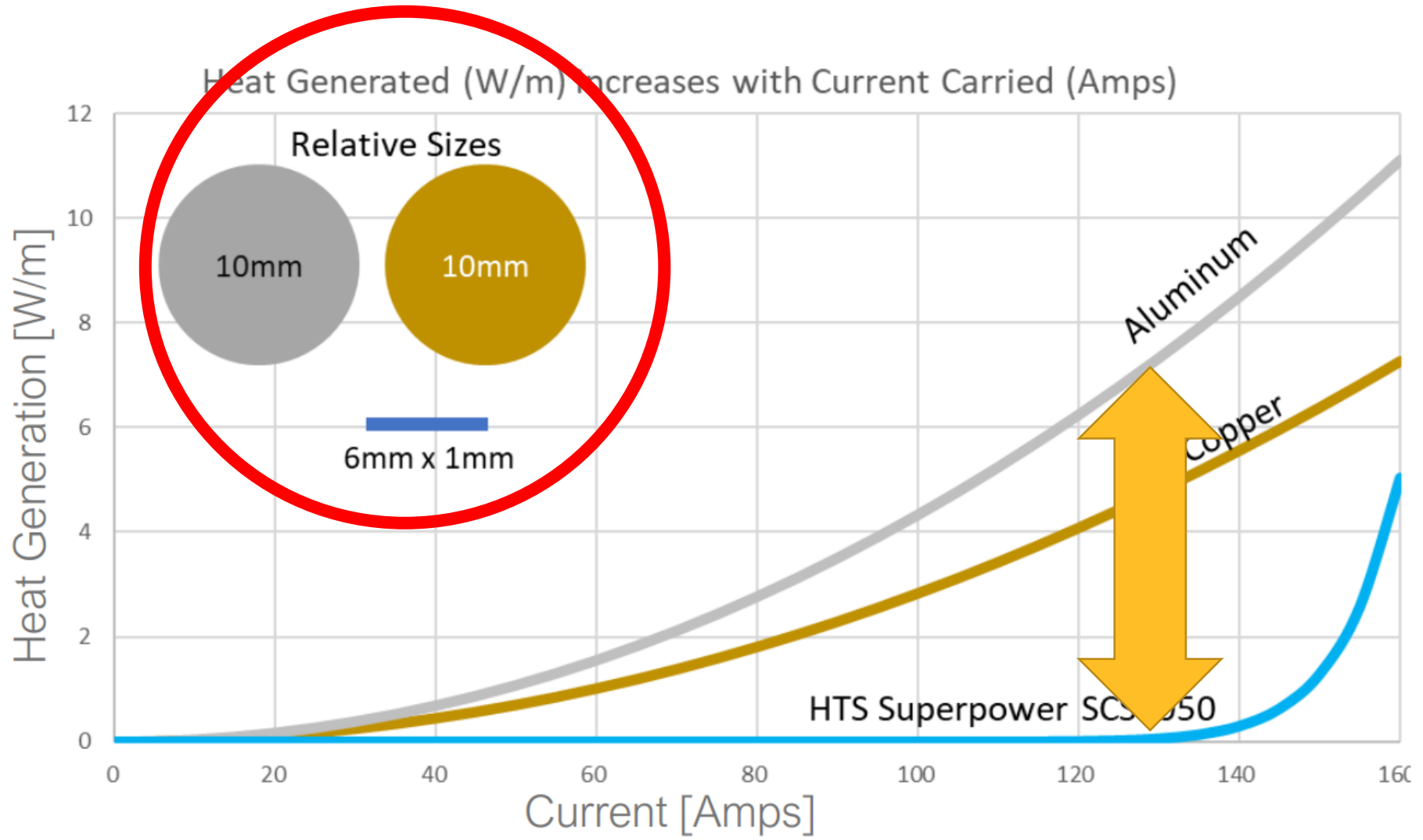
Image credit: SunDrive Solar

# Australia's future transmission networks



**10000**  
km of new  
transmission  
lines

**9-10%**  
loss of  
energy in  
transmission



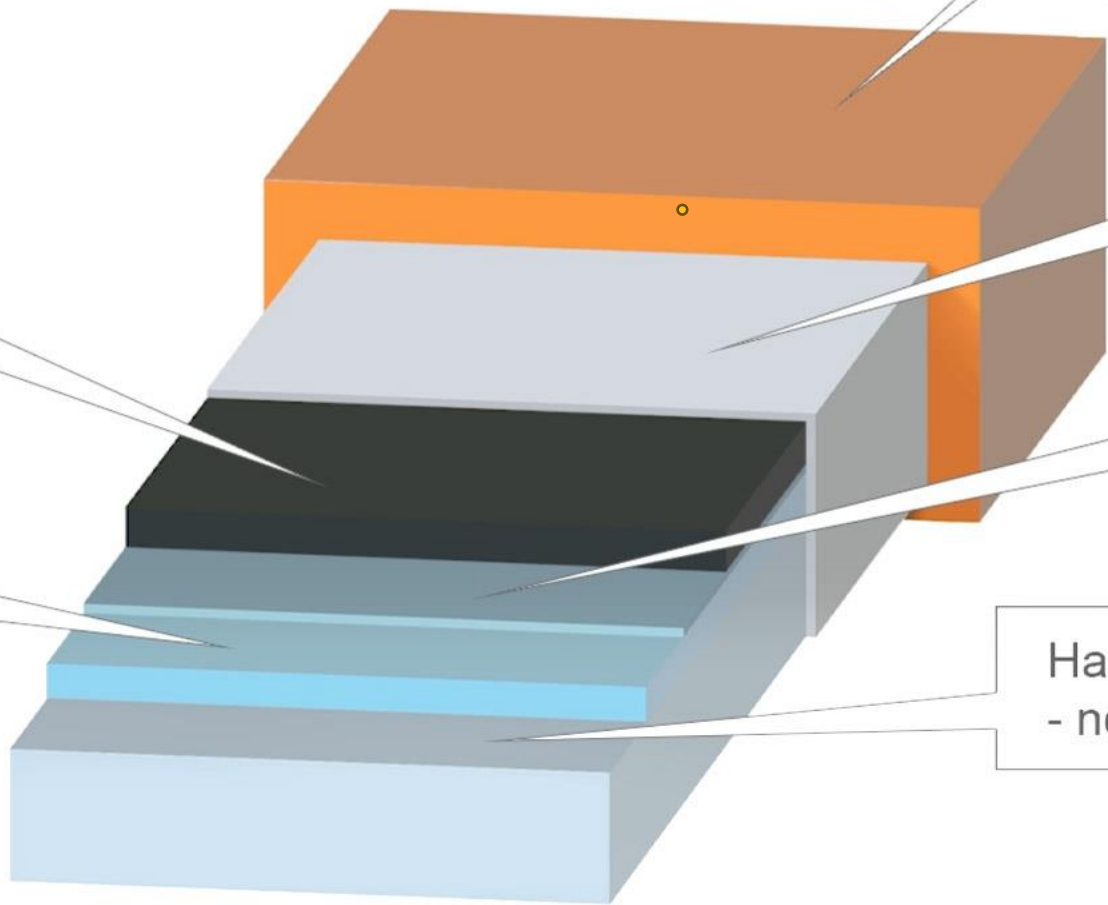
# TPL4000 series:

Surround Copper stabilization for all kinds of applications.

Different materials:  
Ni, YBCO,  
MgO

HTS layer  
- high performance  
functional layer -

First MgO buffer layer  
- textured by inclined  
substrate deposition -



Copper surround coating  
- electrical + mechanical  
stabilization -

Silver surround coating  
- contact layer -

Second MgO buffer layer  
- optimized for HTS  
layer growth -

Hastelloy® C-276 substrate  
- non magnetic, high strength -

Source: VEIR, 2023





Source: VEIR, 2023



# Can we move from a mining country to a materials country?

- Global supply chains for highly processed materials – low volume high value
- What is our ESG advantage?
- Circular economy shifts

# Circular economy

—

# Recycling products - lumps vs matrix

- LUMPS - Lithium, cobalt, tungsten, titanium and rare earths - lumps of materials such as batteries and magnets
  - **Recycling from batteries could reach more than 90% simply**
  - Business case exists for recovering valuable materials in bulk -small amount of energy and waste
- MATRIX - Gallium, indium and germanium - tiny quantities incorporated into other materials as a matrix to produce the desired effect
  - **Critical minerals to dope semiconductors - parts per million level**
  - Recycling is hard
  - Business case for recovering scant quantities through chemical processing requires lots of energy and produces lots of waste
  - Difficult to justify recycling - unless the metal is as highly valuable as platinum or gold

## Current trends

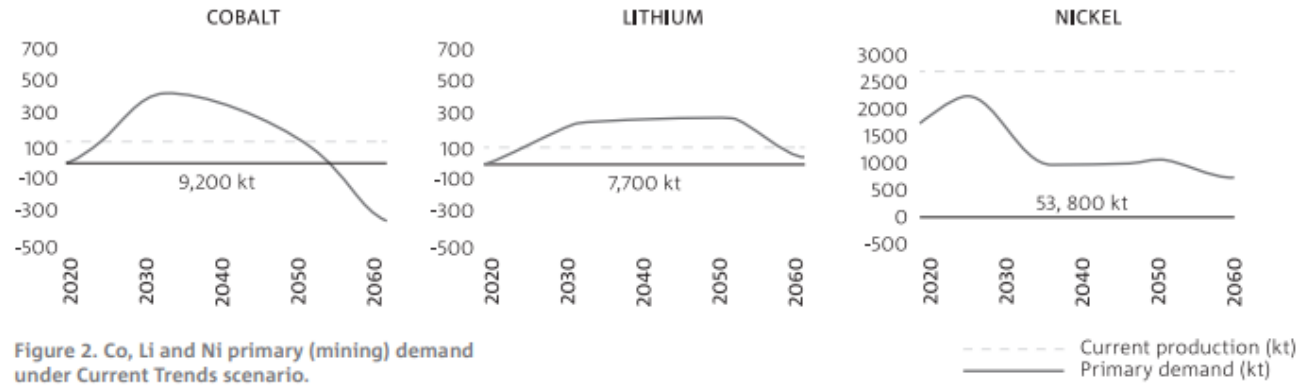


Figure 2. Co, Li and Ni primary (mining) demand under Current Trends scenario.

## Rapid Change

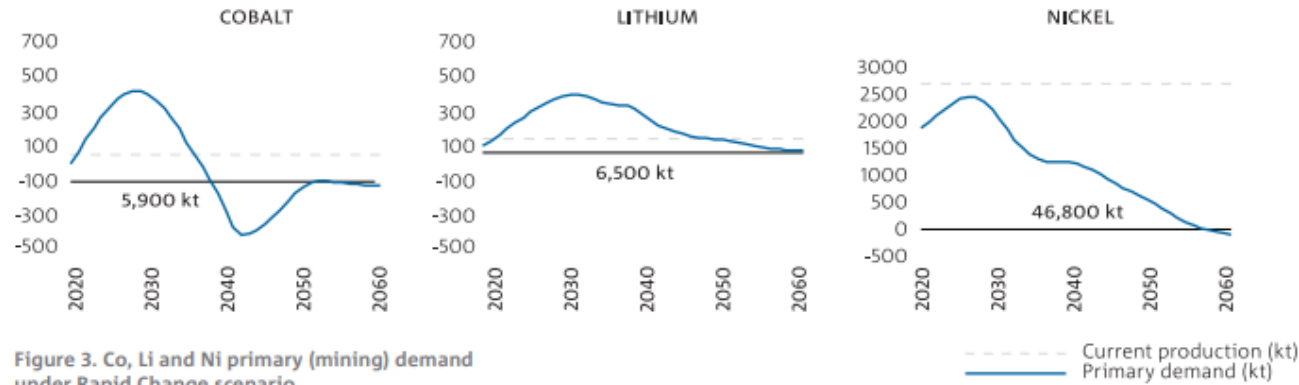


Figure 3. Co, Li and Ni primary (mining) demand under Rapid Change scenario.

## Circular Economy

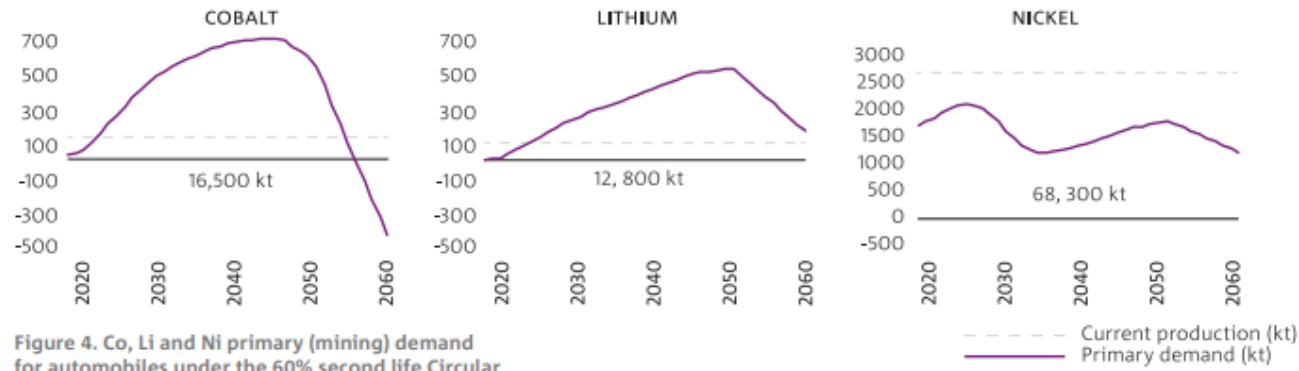


Figure 4. Co, Li and Ni primary (mining) demand for automobiles under the 60% second life Circular Economy scenario.

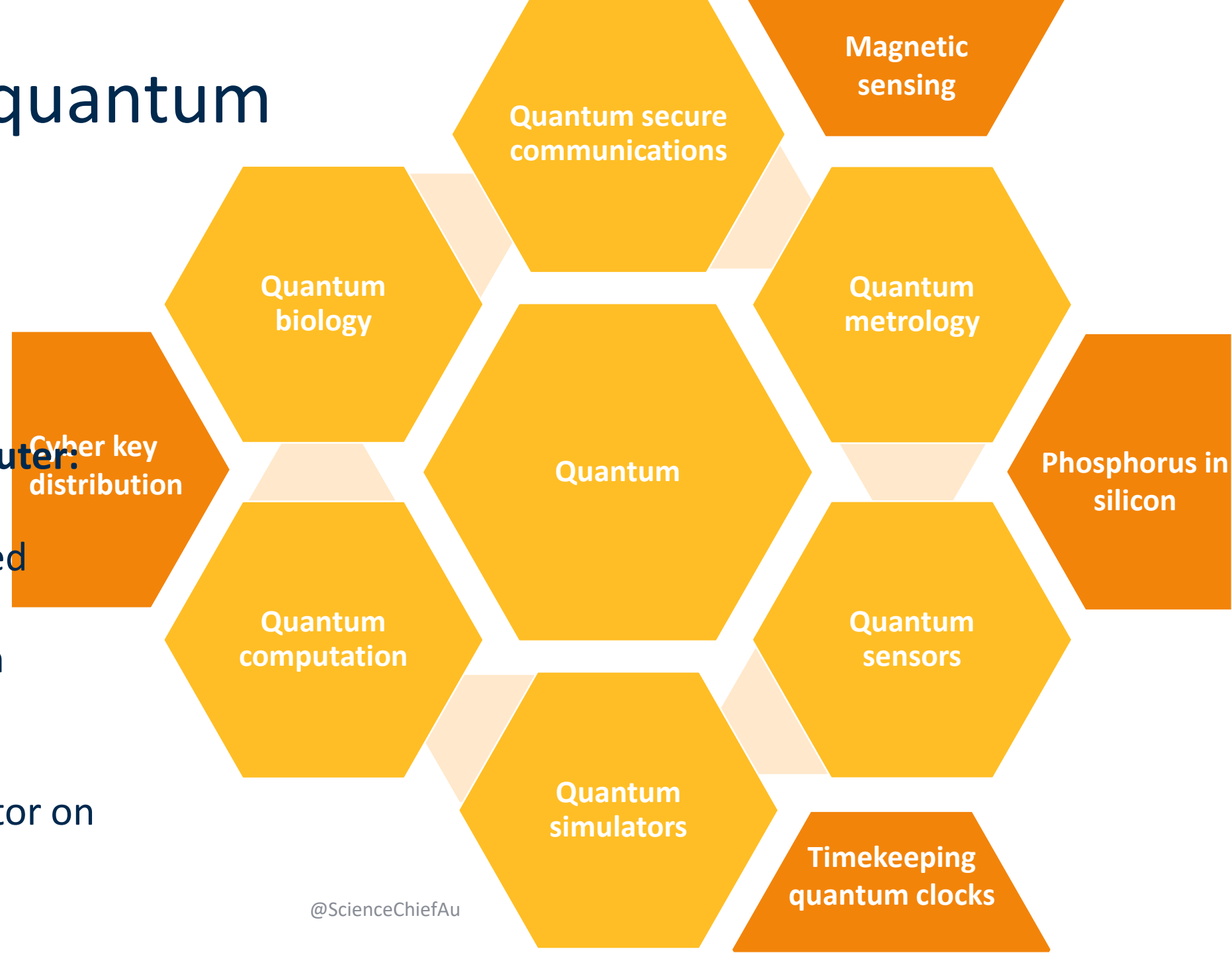
New Tech not covered in this  
conference

**QUANTUM**

# What will quantum deliver?

## Many types of computer:

- Fully error corrected
- Annealers
- Analogue quantum simulations
- NISQ
- Quantum accelerator on HPC



# At a glance: Australia's quantum ecosystem

As at August 2024 unless otherwise noted

 **26** organisations are pursuing quantum technology research

**16**   
universities

**4**   
government research agencies

**6**   
ARC Centres of Excellence

At least **53** facilities and laboratories  related to quantum technology research and development

**38** quantum businesses



Australian-headquartered businesses

Quantum businesses have announced at least

**20** 

new domestic collaborations with partners across several sectors

**17** 

new international collaborations

since the launch of the National Quantum Strategy in May 2023

**13**   
Overseas-headquartered businesses with a presence in Australia

Australia has established

**5** 

quantum-related international arrangements




**27%**

of Australians have heard of quantum technologies

Based on a May 2024 survey of a representative sample of the Australian public

 **24** Australian universities are teaching quantum subjects

**6** offer specialised quantum degrees 

Australian-headquartered quantum businesses have received at least

**\$179 million**

in private investment since the launch of the strategy in May 2023



Public funding for quantum technologies in Australia totals

**\$231 million**

since the launch of the strategy in May 2023

As at 7 November 2024  
Excludes the Australian Government and Queensland Government investment in PsiQuantum

The Australian and Queensland governments announced a joint investment of

**\$940 million**

in PsiQuantum in April 2024



to build its world-leading utility-scale Fault Tolerant Quantum Computer

and establish its Asia-Pacific headquarters in Brisbane

**51**

Since May

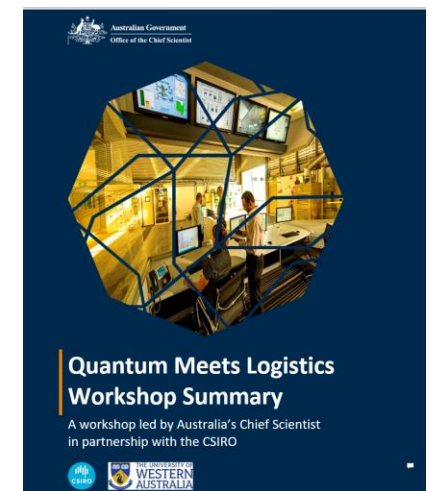
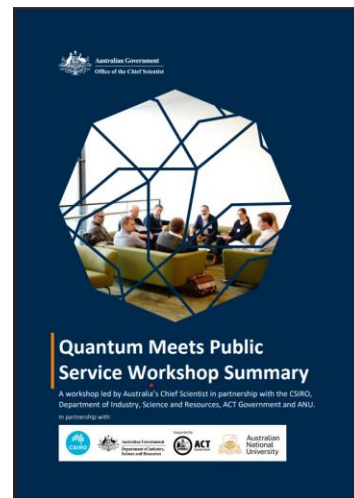
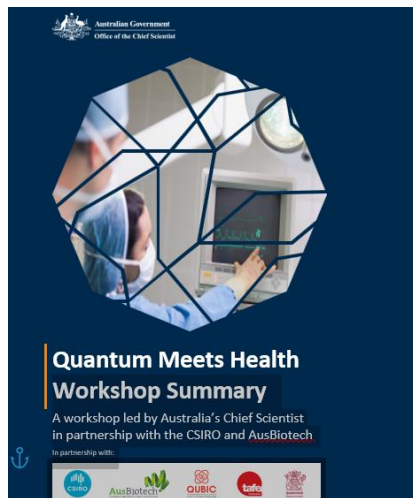
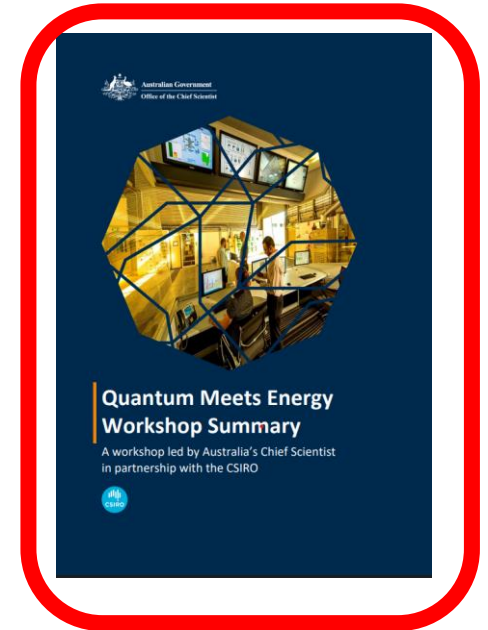
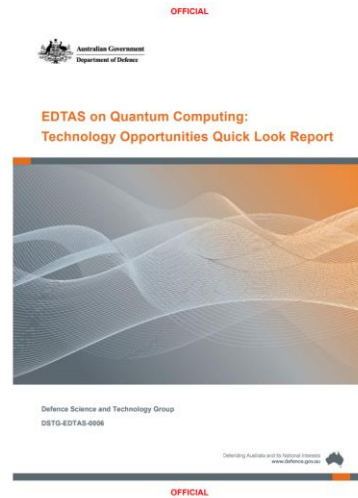
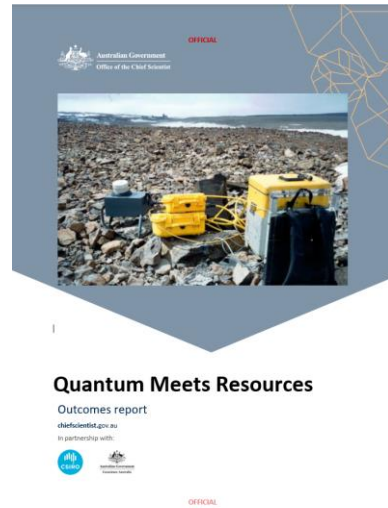
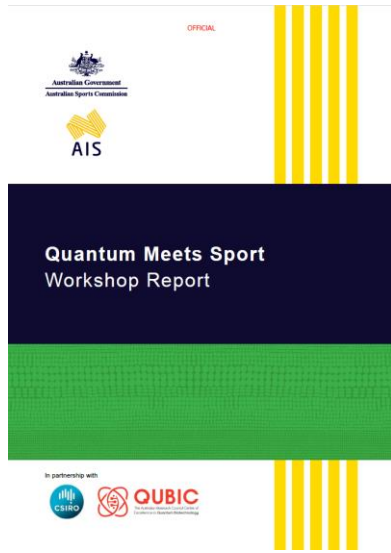
**2023**

**\$1.4B**

+ investments in companies



# Quantum meets report - on line



# Critical Technologies Challenge Program

Solving national challenges using quantum technologies

22 May 2024

[www.business.gov.au/ctcp](http://www.business.gov.au/ctcp)

- *Optimise the performance, sustainability, and security of energy networks to help the transition to Net Zero.*
- *Improve medical imaging and medical sensors to support diagnosis, treatment of disease and monitoring activities inside the human body.*
- *Enhance communication with autonomous systems in varying environments.*
- *Optimise efficiency and reduce the impact of resource exploration, extraction, and mineral processing.*



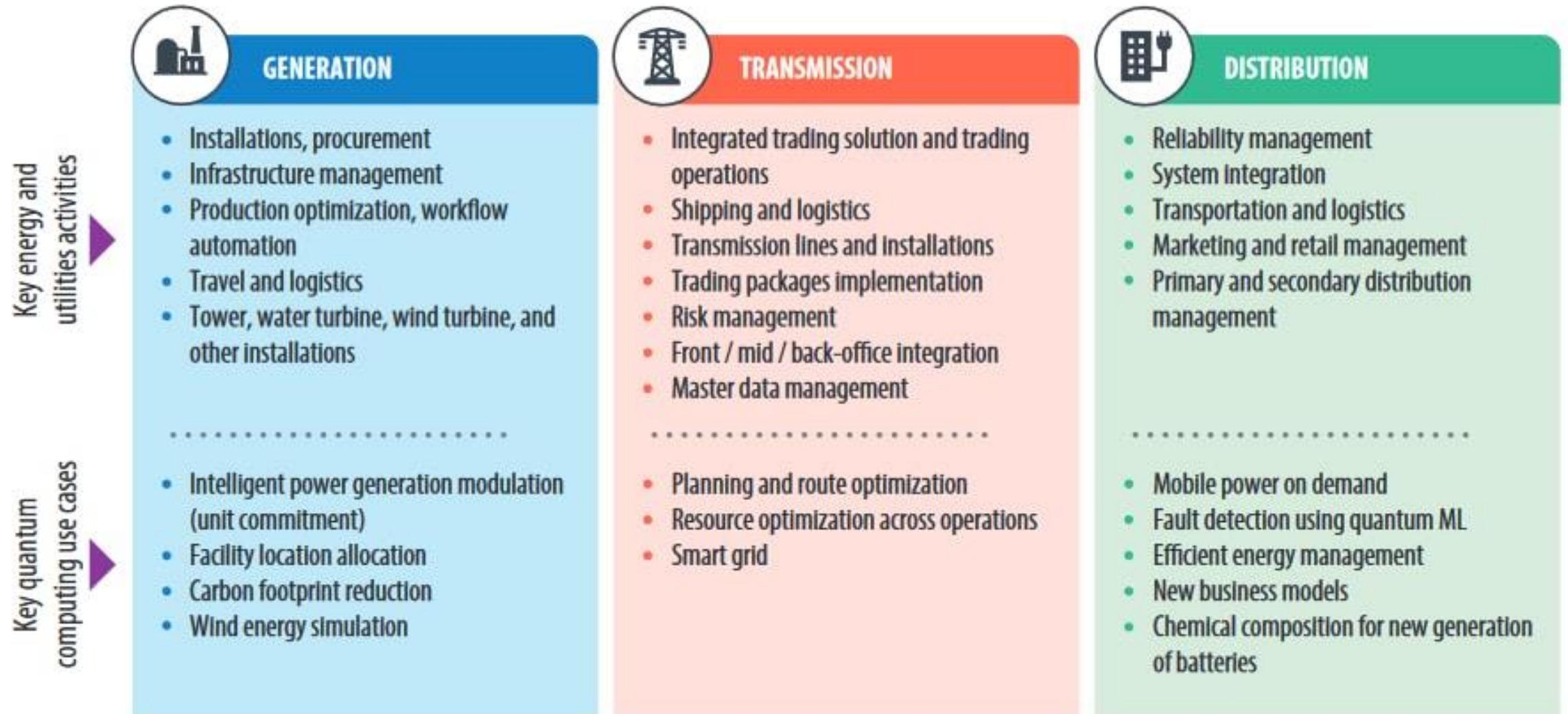
ARTICLE

# Quantum Computing — A Game Changer for The Energy and Utilities Sector

Quantum computing could transform the energy sector in many ways. But the sector is still working out how to optimize quantum computers to best suit its needs. Here, understanding the technology's capabilities and starting small but early are crucial.

- placing power generation facilities appropriately
- deciding which power generation units to fire up
- using quantum ML for fault detection

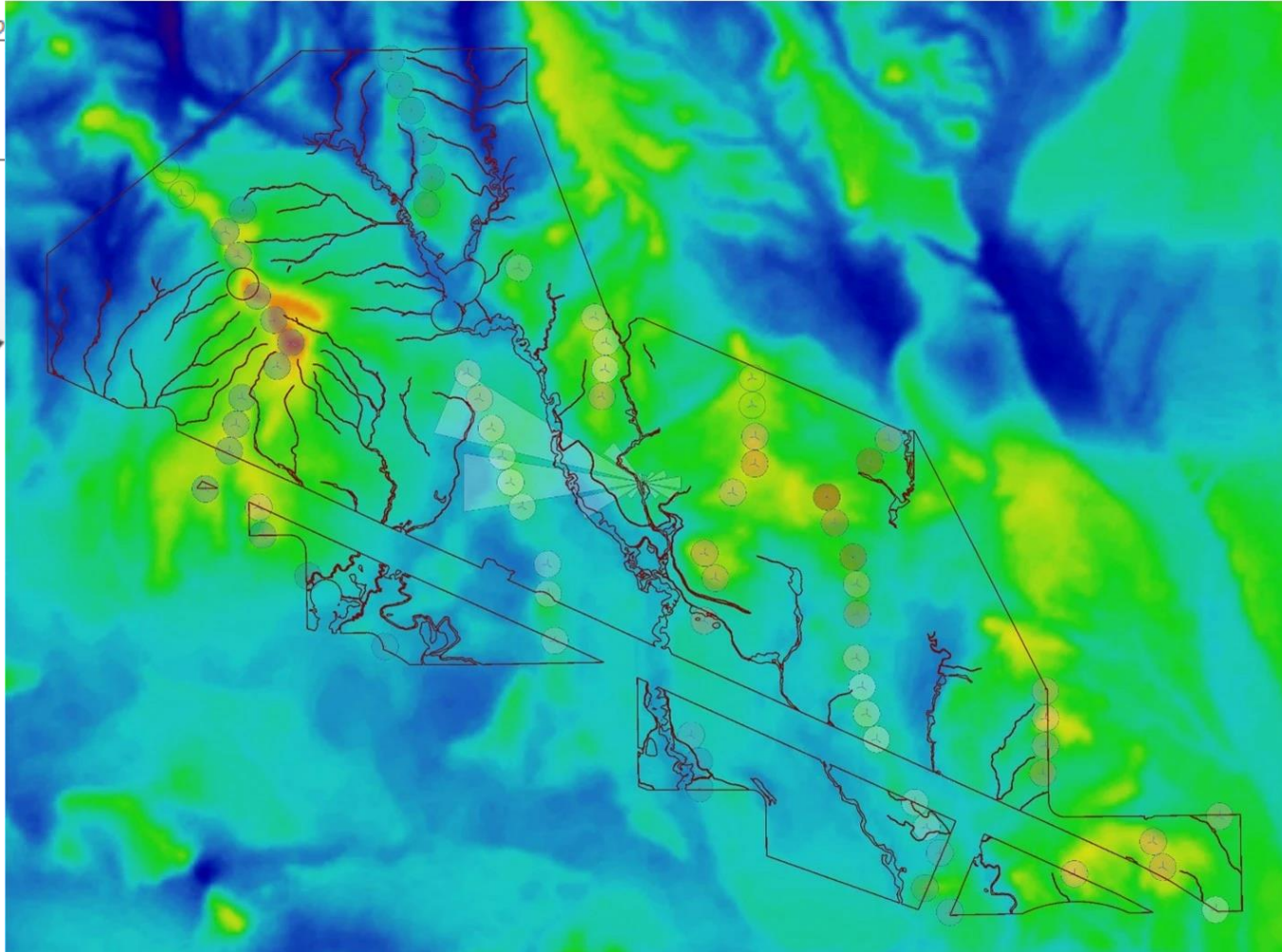
# Energy use cases for quantum



# Qubit Engineering optimizes wind farm energy production with Azure Quantum

May 17, 2024

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Open Access Article

## Exploring Quantum Machine Learning and Feature Reduction Techniques for Wind Turbine Pitch Fault Detection

by Camila Correa-Jullian <sup>1,\*</sup>  , Sergio Cofre-Martel <sup>1</sup>  , Gabriel San Martin <sup>1</sup> ,  
Enrique Lopez Droguett <sup>1,2</sup> , Gustavo de Novaes Pires Leite <sup>3,4</sup>   and Alexandre Costa <sup>4</sup> 

<sup>1</sup> Garrick Institute for the Risk Sciences, University of California, Los Angeles, CA 90095, USA

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<sup>4</sup> Center for Renewable Energy from the Federal University of Pernambuco (CER-UFPE), Recife 50740-540, PE, Brazil



\* Author to whom correspondence should be addressed.

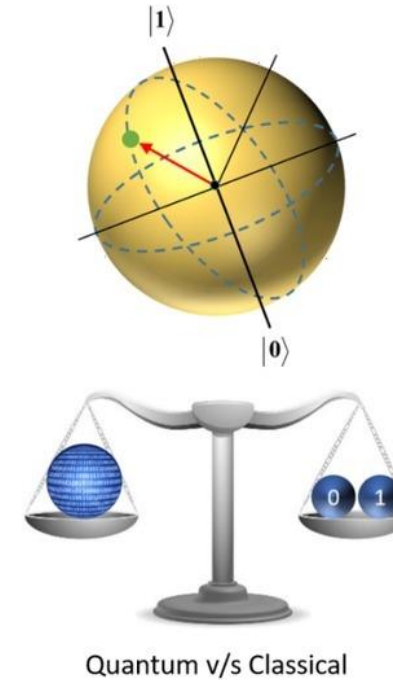
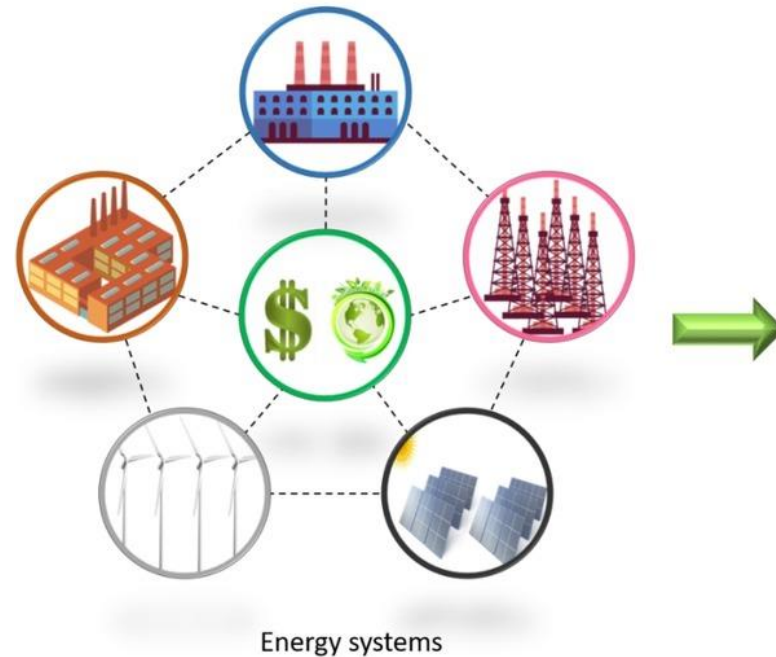
*Energies* **2022**, *15*(8), 2792; <https://doi.org/10.3390/en15082792>

Submission received: 22 March 2022 / Revised: 7 April 2022 / Accepted: 8 April 2022 /

Published: 11 April 2022

# Quantum computing for energy systems optimization: Challenges and opportunities

[Akshay Ajagekar](#), [Fengqi You](#)  



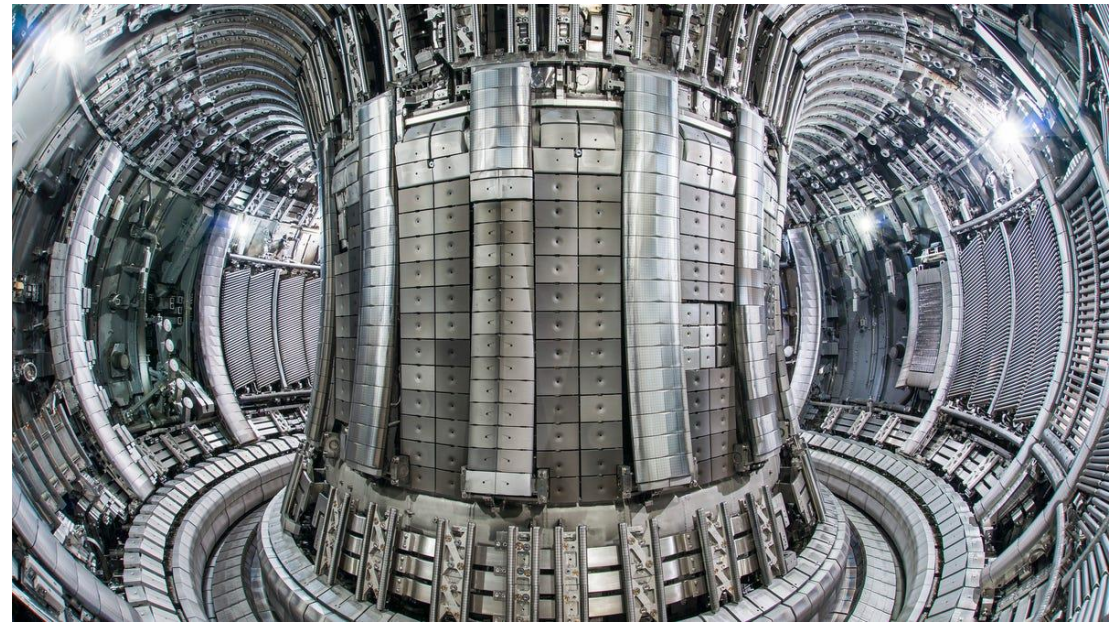
# Designing materials for fusion reactors

The structural materials used in a fusion reactor must address a number of concerns.

- high thermal-stress capability
- compatible with the coolant - may be a liquid metal such as lithium or a gaseous coolant (He)
- passively safe under accident conditions
- environmentally friendly
- resist radiation damage.

There are only a few structural materials that can adequately address all of these concerns.

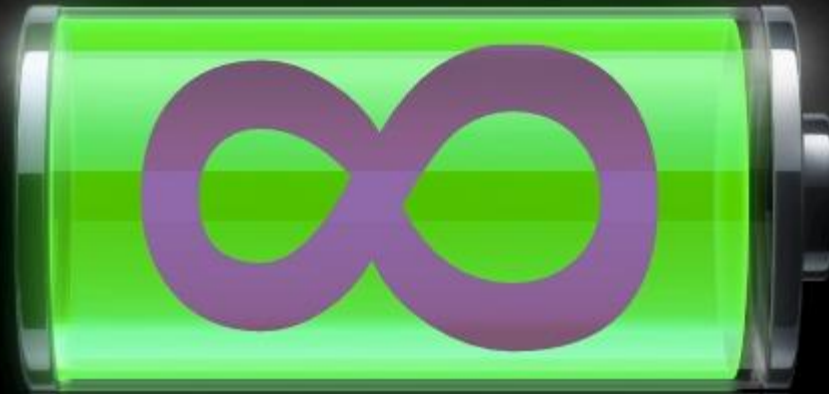
Could Quantum materials design/model a new material?



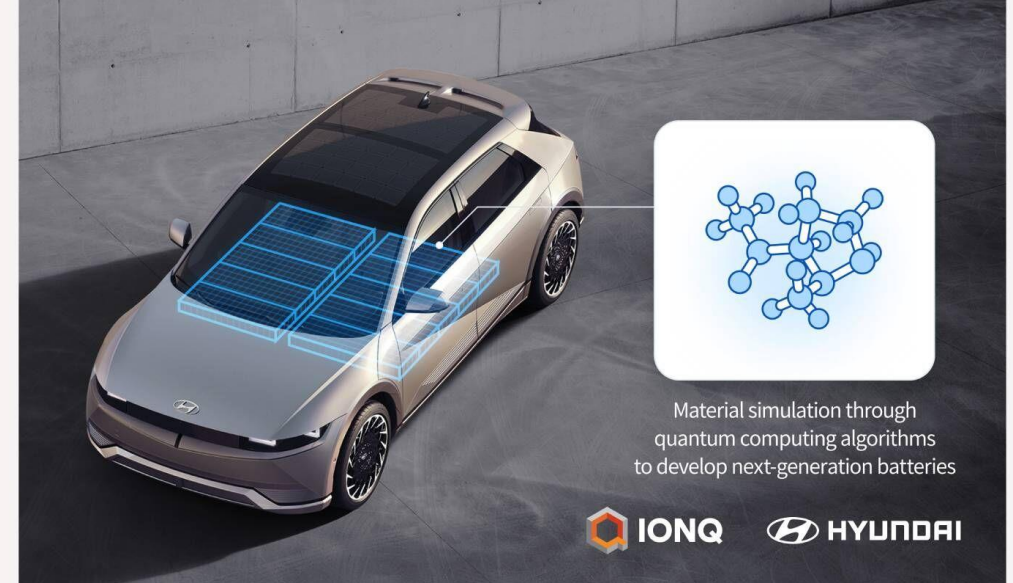


## The Battery that Never Dies:

Science (might) eliminate the need to charge your phone with quantum mechanics!



IBM and Daimler use quantum computer to develop next-gen batteries



## Ford Enlists Quantum Computing in EV Battery Materials Hunt

🕒 March 19, 2023 [Stefano Lovati](#)

Autonomous & SDV | January 19, 2022

## IonQ and Hyundai Motor Partner To Use Quantum Computing To Advance Effectiveness Of Next-Gen Batteries

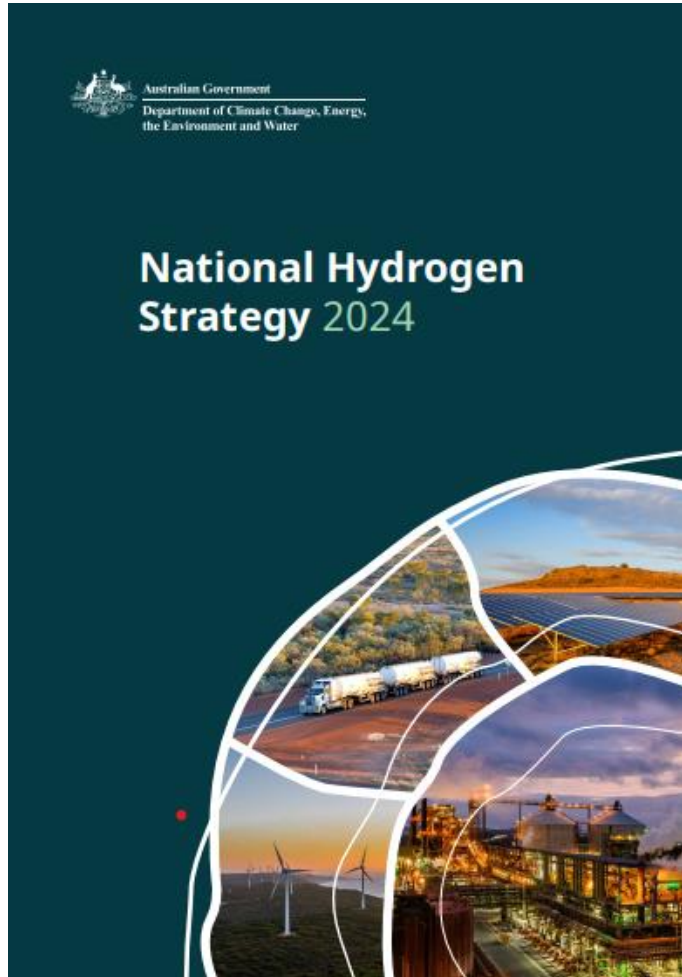
### PsiQuantum, Mercedes-Benz Study How Quantum Computers Can Accelerate EV Battery Design

# Cyber security

## **Protecting Essential Critical Infrastructure**

Whether it's oil rigs, oil transport, electric substations, corporate offices, or other critical infrastructure locations, energy and utility companies are faced with challenges to protect their essential assets and energy grids against natural disasters, theft, and cyber threats and to meet strict regulations. Yet, traditional security solutions lack the performance, resilience, and automation needed for companies to meet both physical and cyber security requirements.

# HYDROGEN



## Vision

A clean, innovative, safe and competitive hydrogen industry that benefits Australia's communities and economy, enables our net zero transition, and positions us as a global hydrogen leader

## Objectives



### Supply

Australia's hydrogen industry is globally cost-competitive  
(Chapter 2)



### Demand

Identify and support the most prospective hydrogen demand sectors  
(Chapter 3)



### Community benefit

Communities are aware of and realise the benefits of hydrogen  
(Chapter 4)



### Trade, investment and partnerships

Establish trade at scale and leverage purposeful partnerships  
(Chapter 5)

Fight back – use the evidence

- patience and hold steady
- not Australia's strength

**THE AUSTRALIAN** 

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HOME NATION WORLD BUSINESS HEALTH COMMENTARY SPORT ARTS VIDEO

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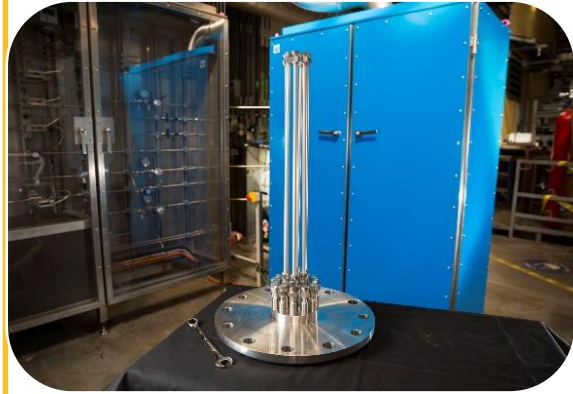
**Green hydrogen hopes up in smoke**

# Jobs Report Guides Future For The Clean Energy Workforce

The Clean Energy Council supports the findings of the inaugural workforce capacity study, The Clean Energy Generation: Workforce needs for a net zero economy, published by Jobs and Skills Australia.

Australia will need an additional 32,000 electricians by 2030, with potential growth to 85,000 by 2050

# Future industries



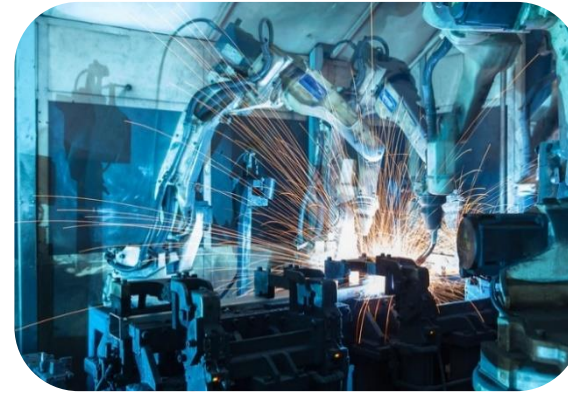
## Australian hydrogen industry

8,000 jobs



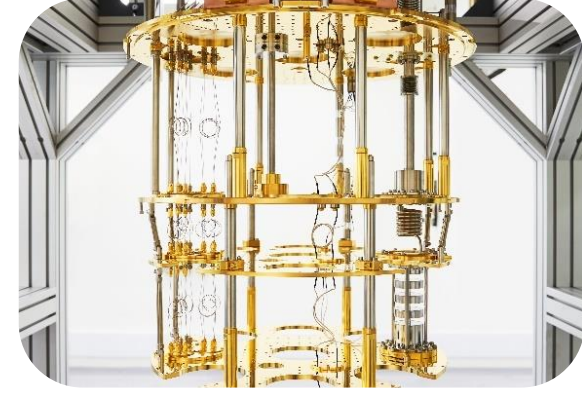
## Space

Triple the size of the sector by 2030



## AI and machine learning

1 million tech jobs by 2025



## Quantum technology sector

16,000 jobs by 2040

# Skills issues

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School student pipeline and enough teachers

High standard of education, research, D&I, culture of innovation and entrepreneurship

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Engineering short supply only 3%

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Digital has grown by 66% but not enough

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Uneven distribution of skills regionally

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# Government

# Standing in the shoes of government

Election in the next 2 days

Mis and dis information impacting society – social cohesion, threat to democracy

Urgently need to get to 83% renewables in the power grid by 2030

Cost of living is front of mind – thwarting efforts

Low unemployment

99% of businesses are SMEs with 70% less than 20 people

Great at startups and not growing them to medium then global companies  
Only 2% businesses work with unis

Most PhDs work in the service industries not innovation ones

Kids not doing STEM subjects in last years of high school

Skills shortages in specific areas and locations

Education system is not joined up


Still strong perception “there are no jobs in science”

Science does not win votes?

Multi-disciplinary, multi-portfolio problems in a siloed system

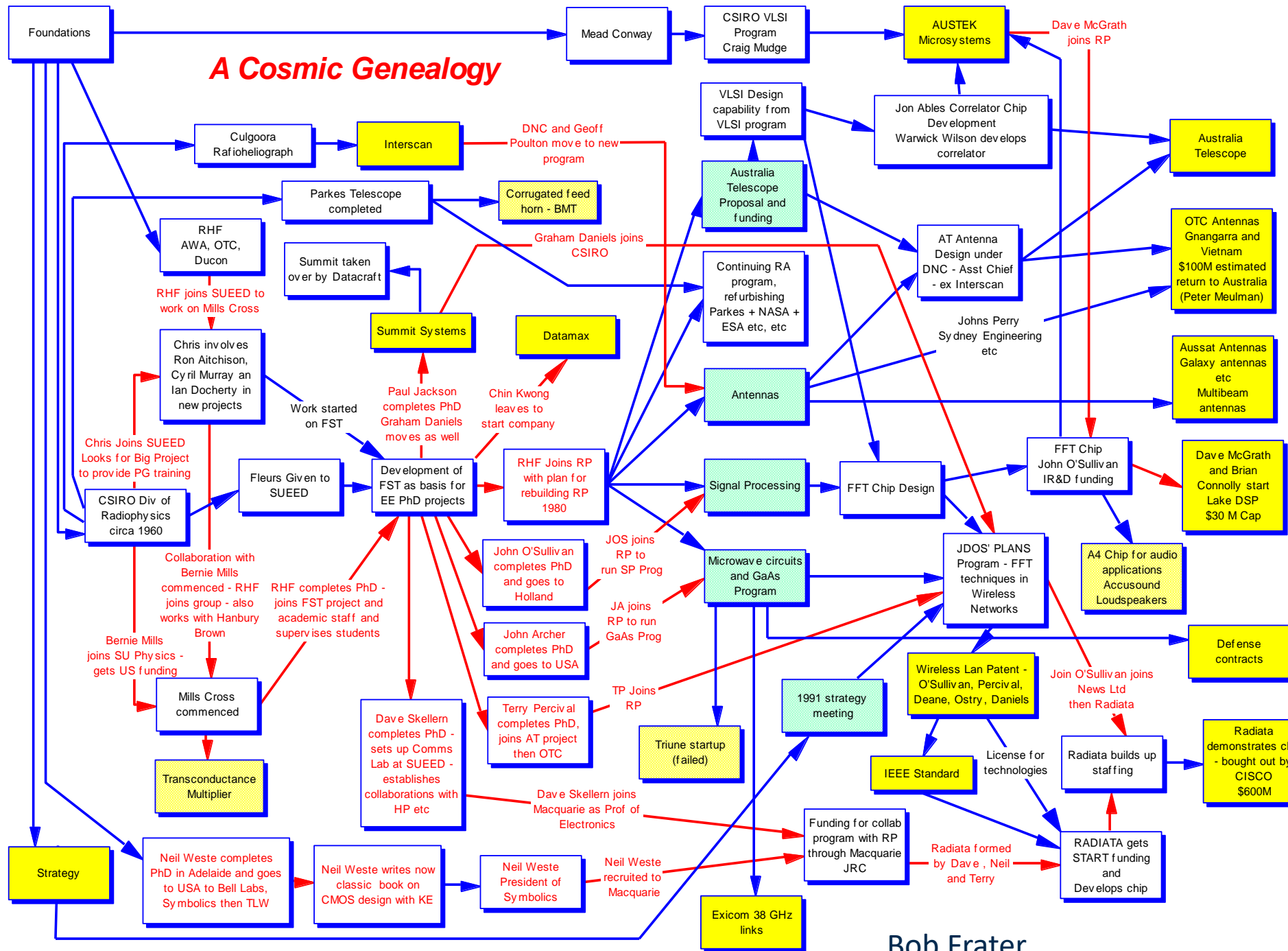
Gendered workplaces

**Rapidly changing geopolitics**



*“Science does not progress in an easy, linear fashion. It's not like you have an idea, set up an experiment, prove your theory and then cure cancer.”*

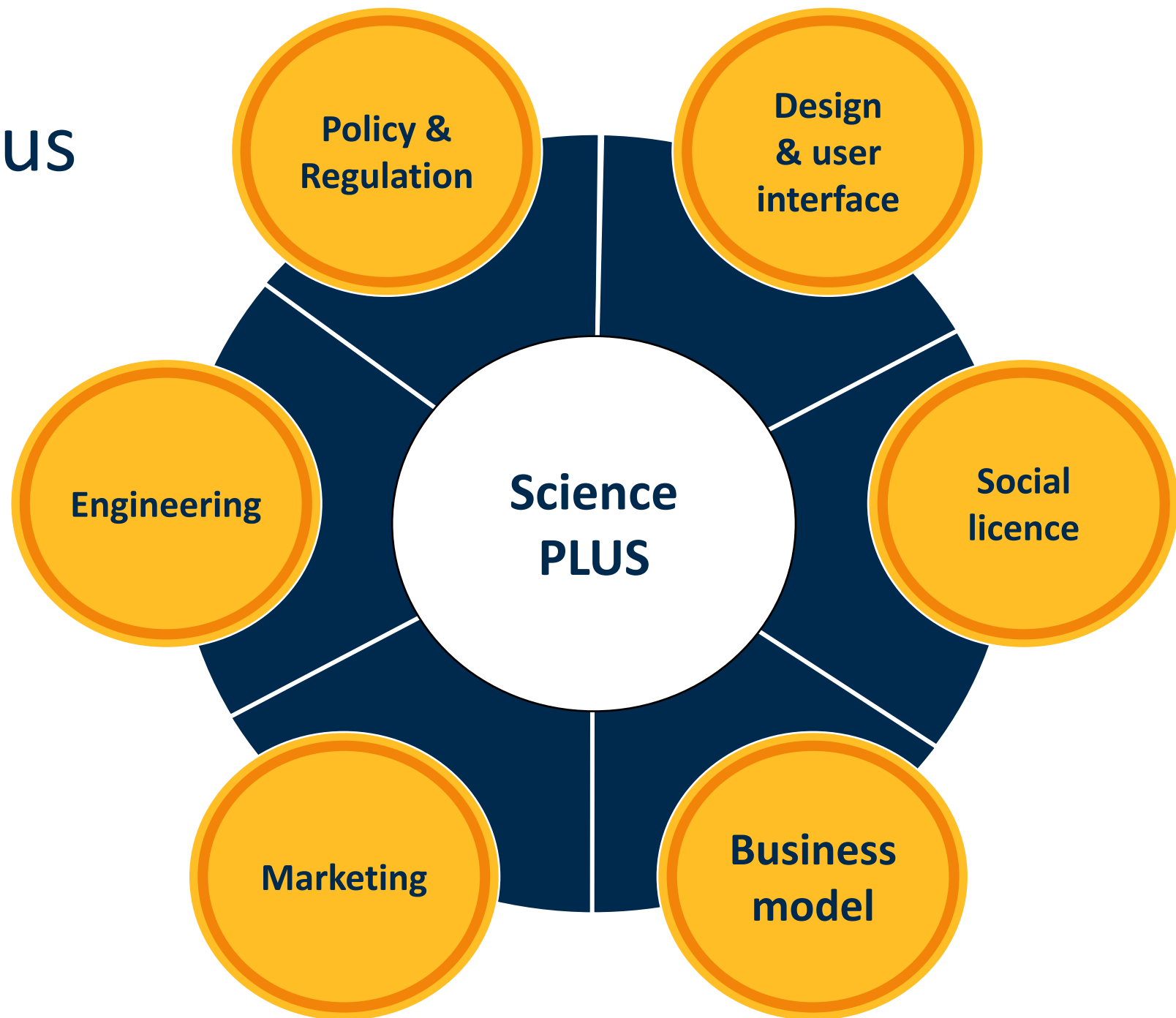
# A Cosmic Genealogy



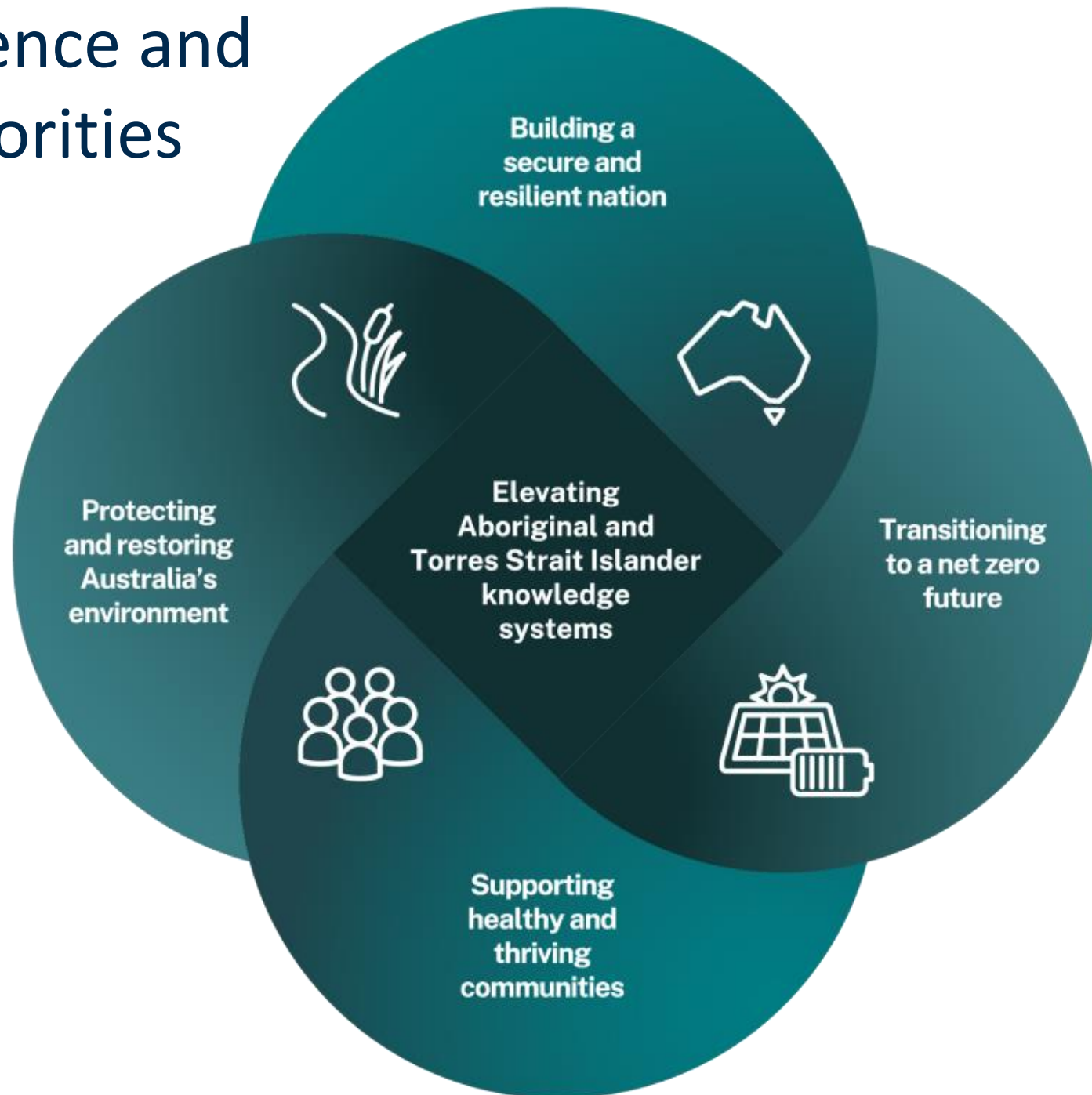
- Far from linear
- Skills and training
- Fundamental science
- Ecosystem
  - Unis
  - PFRAs
  - Start ups
  - Multinationals
  - Standards
  - Regulations

Bob Frater

# Science Plus

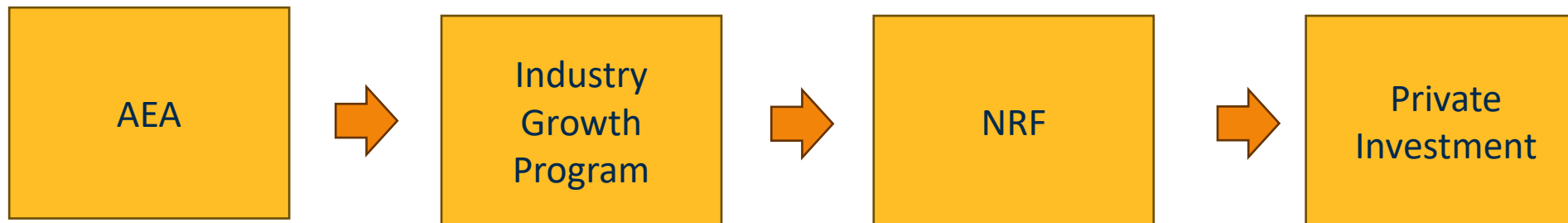


# National Science and Research Priorities



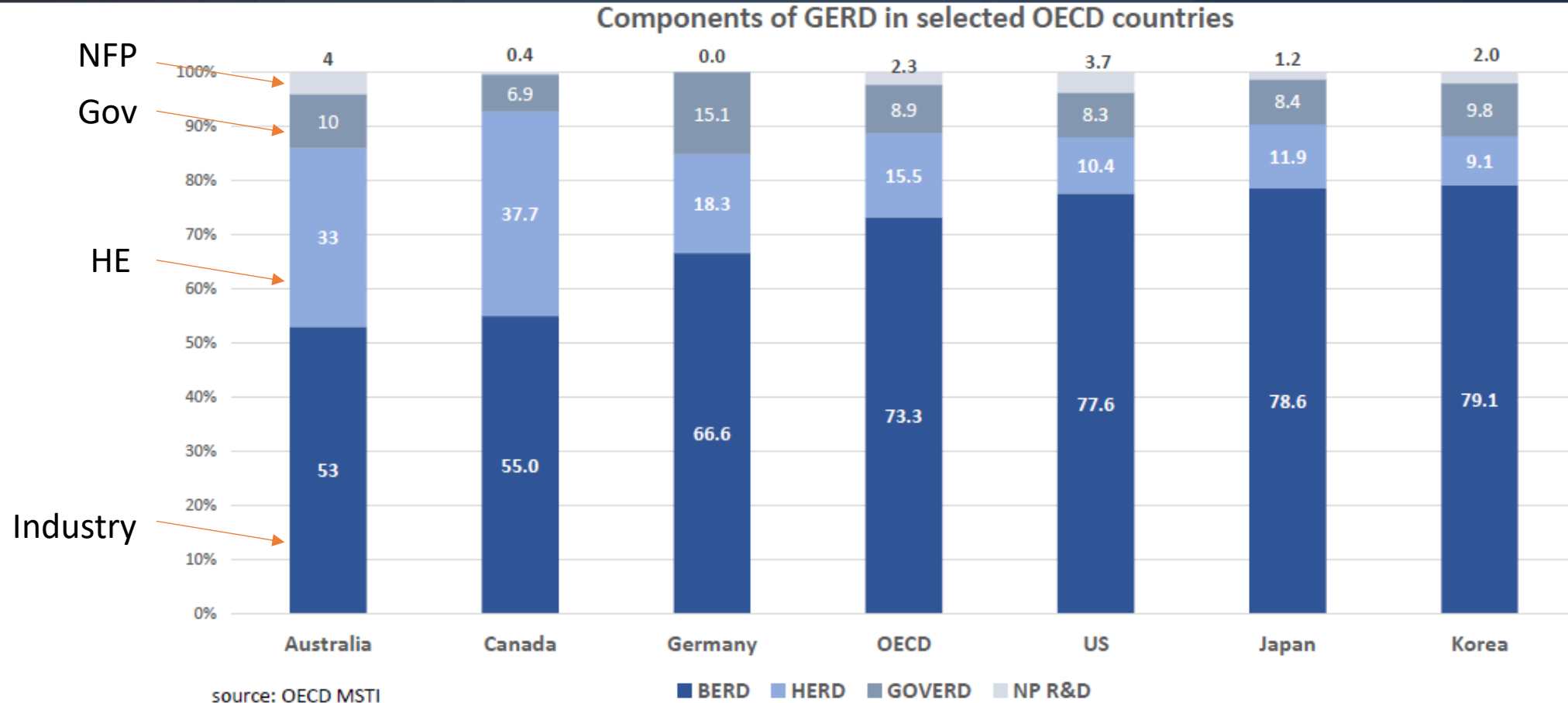
# Government initiatives

- **\$15B National Reconstruction Fund** – including \$1bn to develop and commercialise critical tech
- **\$60M for Critical Technologies Challenge Program and an Australian Centre for Quantum Growth**
- **Defence Advanced Strategic Capabilities Accelerator** – \$3.4B over a decade
- **Australia's Economic Accelerator (AEA)** – \$1.6B to support university research translation
- **National Collaborative Research Infrastructure Strategy** – funding for national-scale research infrastructure
- **\$392.4M Industry Growth Program** for small and medium enterprises (SMEs) and startups.



# Growing BERD will increase total R&D intensity

## Currently the lowest in the OECD



- The main determinants of GERD (gross R&D) are BERD and HERD. Together they account for over 84 per cent of total R&D in peer economies. Australia is heavily reliant on Higher Education R&D.



Can we change Australia from a mining country to a materials and deep tech country?

Will we be bold, persistent and patient enough?

# In conclusion...

- We need to change our tactics to get to 2050 deadline
- We need a multi decadal plan
- The energy transition needs more materials and use all the tech options available
- Mining will need to remain agile and consider broader operating environment & new technologies in future planning
- Circular economy will have an impact on primary materials demand
- Skills an issue
- Invest
- Stay the course

— Analysis

# Australia is rich, smart and getting smarter



**Aaron Patrick**

*Senior correspondent*

2025

Australia has astonished all expectations and rushed up the Harvard economic complexity list resulting from the success of the energy transition, semiconductor, quantum and photonics, engineered biology, materials industry explosion.

Since I wrote this column in 2019, this science and tech has become the new basis for Australia's new economy and driving the response to climate change.

But rather can we be wise and  
get wiser?

Thank you